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Water Monitoring Management

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RARITAN and SANDY HOOK BAYS

SANITARY SURVEY REPORT

1994-1997

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RARITAN and SANDY HOOK BAYS

SANITARY SURVEY REPORT (1994- 1997)

New Jersey Department of Environmental Protection
ROBERT C. SHINN, Jr.
COMMISSIONER

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EXECUTIVE SUMMARY

This report is a Sanitary Survey of the Raritan and Sandy Hook Bay. A Sanitary Survey is completed every 12 years for each designated growing area. The report also addresses a request from the shellfish industry to review the water quality of the *Prohibited* waters at the eastern and western portions of the area. Improvements in water quality in these areas might lead to an upgrade to the *Special Restricted* category. Such an upgrade would allow the shellfish resources to be utilized under the special permits program for depuration and relay.

Sampling results (1994-1997) indicate that the total coliform bacterial water quality of the shellfish growing waters of the Raritan and Sandy Hook Bays has not significantly changed since the last re-evaluation report (1989-1994) completed in February 1996. There appears to be an overall improvement in bacterial water quality in the Sandy Hook Bay during the summer sampling season (May-October). Additional samples should be collected and analyzed under the adverse pollution condition of rainfall to properly assess this trend. Bacterial water quality of the *Prohibited* waters meets the criteria for *Special Restricted* classification. However, additional sampling and analysis for the presence of metals and other pollutants in shellfish tissue should take place before any upgrade occurs. It is recommended that the present classification remain unchanged.

INTRODUCTION

PURPOSE

The report is part of a series of studies having a dual purpose. The first and primary purpose is to comply with the guidelines of the National Shellfish Sanitation Program (NSSP) that are established by the Interstate Shellfish Sanitation Conference (ISSC). Reports generated under this program form the basis for classifying shellfish waters for the purpose of harvesting shellfish for human consumption. As such, they provide a critical link in public health issues involving the consumption of molluscan shellfish.

The second purpose is to provide input to the State Water Quality Inventory Report, which is prepared pursuant to Section 305(b) of the Federal Clean Water Act (P.L. 95-217). The information contained in the growing area reports is used for the New Jersey State Water Quality Inventory Report (305b) which provides an assessment to Congress every two years of current water quality conditions in the State's major rivers, lakes, estuaries, and ocean waters. The reports provide valuable information for the 305(b) report, which describes the waters that are attaining state designated water uses and national clean water goals; the pollution problems identified in surface waters; and the actual or potential sources of pollution. Similarly, the reports utilize relevant information contained in the 305(b)

report, since the latter assessments are based on instream monitoring data (temperature, oxygen, pH, total and fecal coliform bacteria, nutrients, solids, ammonia and metals), land-use profiles, drainage basin characteristics and other pollution source information.

From the perspective of the Shellfish Classification Program, the reciprocal use of water quality information from reports represent two sides of the same coin: the growing area report focuses on the estuary itself, while the 305(b) report describes the watershed that drains to that estuary.

The Department participates in a cooperative National Environmental Performance Partnership System (NEPPS) with the USEPA which emphasizes ongoing evaluation of issues associated with environmental regulation, including assessing impacts on water bodies and measuring improvements in various indicators of environmental health. The shellfish growing area reports are intended to provide a brief assessment of the growing area, with particular emphasis on those factors that affect the quantity and quality of the shellfish resource. As the Department implements a comprehensive watershed management program in conjunction with the NEPPS initiative, the shellfish growing area reports provide valuable information on the overall quality of the saline waters in the most downstream sections of each major watershed. In addition, the reports assess the quality of the biological resource and provide a reliable indicator of potential areas of concern and/or areas where additional information is needed to accurately assess watershed dynamics.

HISTORY

As a brief history, the NSSP developed from public health principles and program controls formulated at the original conference on shellfish sanitation called by the Surgeon General of the United States Public Health Service in 1925. This conference was called after oysters were implicated in causing over 1500 cases of typhoid fever and 150 deaths in 1924. The tripartite cooperative program (federal, state and shellfish industry) has updated the program procedures and guidelines through workshops held periodically until 1977. Because of concern by many states that the NSSP guidelines were not being enforced uniformly, a delegation of state shellfish officials from 22 states met in 1982 in Annapolis, Maryland, and formed the ISSC. The first annual meeting was held in 1983 and continues to meet annually at various locations throughout the United States.

The *Guide for the Control of Molluscan Shellfish* (1997) sets forth the principles and requirements for the sanitary control of shellfish produced and shipped in interstate commerce in the United States. They provide basis used by the Federal Food and Drug Administration (FDA) in evaluating state shellfish sanitation programs. There are five major points on which the state is evaluated by the FDA include:

l. The classification of all actual and potential shellfish growing areas as to their suitability for shellfish

harvesting.

2. The control of the harvesting of shellfish from areas that are classified as restricted, prohibited or otherwise closed.
3. The regulation and supervision of shellfish resource recovery programs.
4. The ability to restrict the harvest of shellfish from areas in a public health emergency, and
5. Prevent the sale, shipment or possession of shellfish that cannot be identified as being produced in accordance with the NSSP and have the ability to condemn, seize or embargo such shellfish.

FUNCTIONAL AUTHORITY

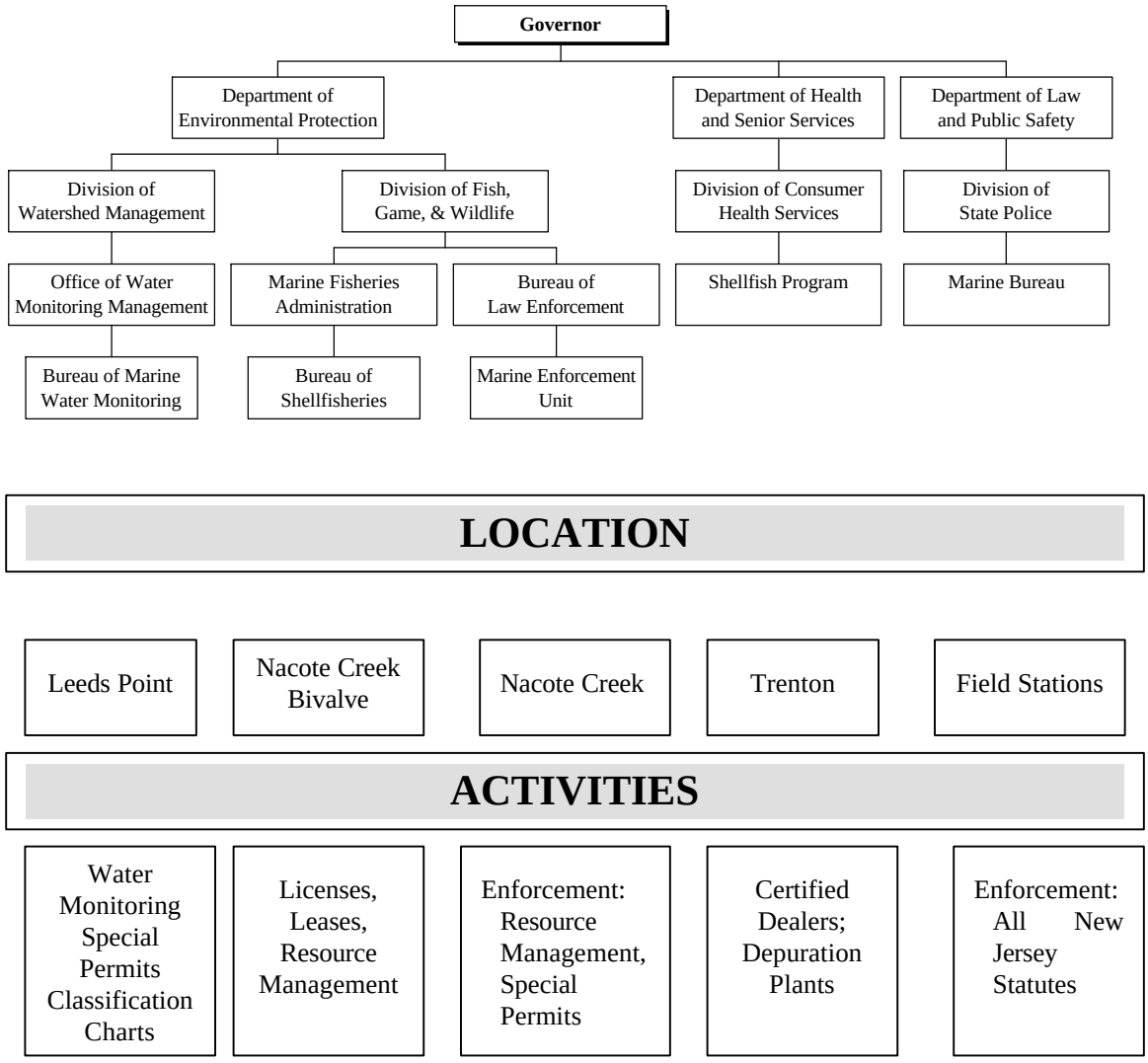
The authority to carry out these functions is divided between the Department of Environmental Protection (DEP), the Department of Health and Senior Services, and the Department of Law and Public Safety. The Bureau of Marine Water Monitoring (BMWM) under the authority of N.J.S.A. 58:24 classifies the shellfish growing waters and administers the special resource recovery programs. Regulations delineating the growing areas are promulgated at N.J.A.C. 7:12 and are revised annually. Special Permit rules are also found at N.J.A.C. 7:12 and are revised as necessary.

The Bureau of Shellfisheries in the Division of Fish, Game and Wildlife issues harvesting licenses and leases for shellfish grounds under the Authority of N.J.S.A. 50:2 and N.J.A.C. 7:25. This bureau in conjunction with the BMWM administers the Hard Clam Relay Program.

The Bureau of Law Enforcement in the DEP (Division of Fish, Game, and Wildlife) and the Division of State Police in the Department of Law and Public Safety enforce the provisions of the statutes and rules mentioned above.

The Department of Health and Senior Services is responsible for the certification of wholesale shellfish establishments and in conjunction with the BMWM, administers the depuration program.

FIGURE 1: STATE OF NEW JERSEY SHELLFISH AGENCIES



IMPORTANCE OF SANITARY CONTROL OF SHELLFISH

Emphasis is placed on the sanitary control of shellfish because of the direct relationship between pollution of shellfish growing areas and the transmission of diseases to humans. Shellfish borne infectious diseases are generally transmitted via a fecal-oral route. The pathway is complex and quite circuitous. The cycle usually begins with fecal contamination of the shellfish growing waters. Sources of such contamination are many and varied. Contamination reaches the waterways via runoff and direct discharges.

Clams, oysters and mussels pump large quantities of water through their bodies during the normal feeding process. During this process the shellfish also concentrate microorganisms, which may

include pathogenic microbes, and toxic heavy metals/chemicals. It is imperative that a system is in place to reduce the human health risk of consuming shellfish from areas of contamination.

Accurate classifications of shellfish growing areas are completed through a comprehensive sanitary survey. The principal components of the sanitary survey report include:

1. An evaluation of all actual and potential sources of pollution,
2. An evaluation of the hydrography of the area and
3. An assessment of water quality. Complete intensive sanitary surveys are conducted every 12 years with interim narrative evaluations completed on a three year basis. If major changes to the shoreline or bacterial quality occur, then the intensive report is initiated prior to its l2 year schedule.

The following narrative constitutes this bureau's assessment of the above mentioned components and determines the current classification of the shellfish growing waters.

BACKGROUND AND DESCRIPTION

This growing area encompasses the shellfish waters of Sandy Hook Bay and Raritan Bay. The area extends from the Highlands Bridge northward to Sandy Hook and westward to the Raritan River. The distance from the Highlands Bridge to the mouth of the Raritan River is approximately 17 miles. To the north the area terminates along the New York State Boundary Line. The shellfish resources are harvested from an area covering approximately 7438 acres (11.6 square miles) of *Special Restricted* shellfish waters.

Raritan Bay (22,400 acres) is located adjacent to the nation's most-concentrated urban population. Sandy Hook Bay (7,680 acres) is located to the east, is contiguous with, and empties into, Raritan Bay. The area is shown on Shellfish Growing Water Classification Chart 1

Sandy Hook Bay is triangular in shape, and extends from the shore at Leonardo, approximately two miles into the bay. On the northwest side of the triangle is the Earle Naval Weapons pier. Sandy Hook borders the eastern side of the bay. This narrow peninsula or spit separates the bay from the Atlantic Ocean. At the outer tip of Sandy Hook are Fort Hancock and the United States Coast Guard installation. The remainder of the peninsula is part of the Gateway National Recreation Area. The communities of Highlands, Atlantic Highlands, and Leonardo border the southern shoreline of Sandy Hook Bay.

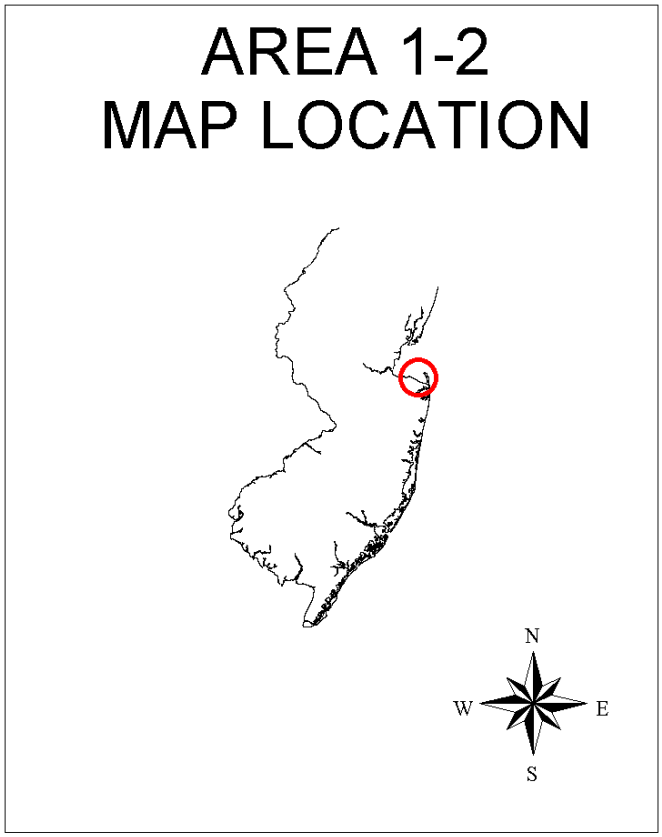
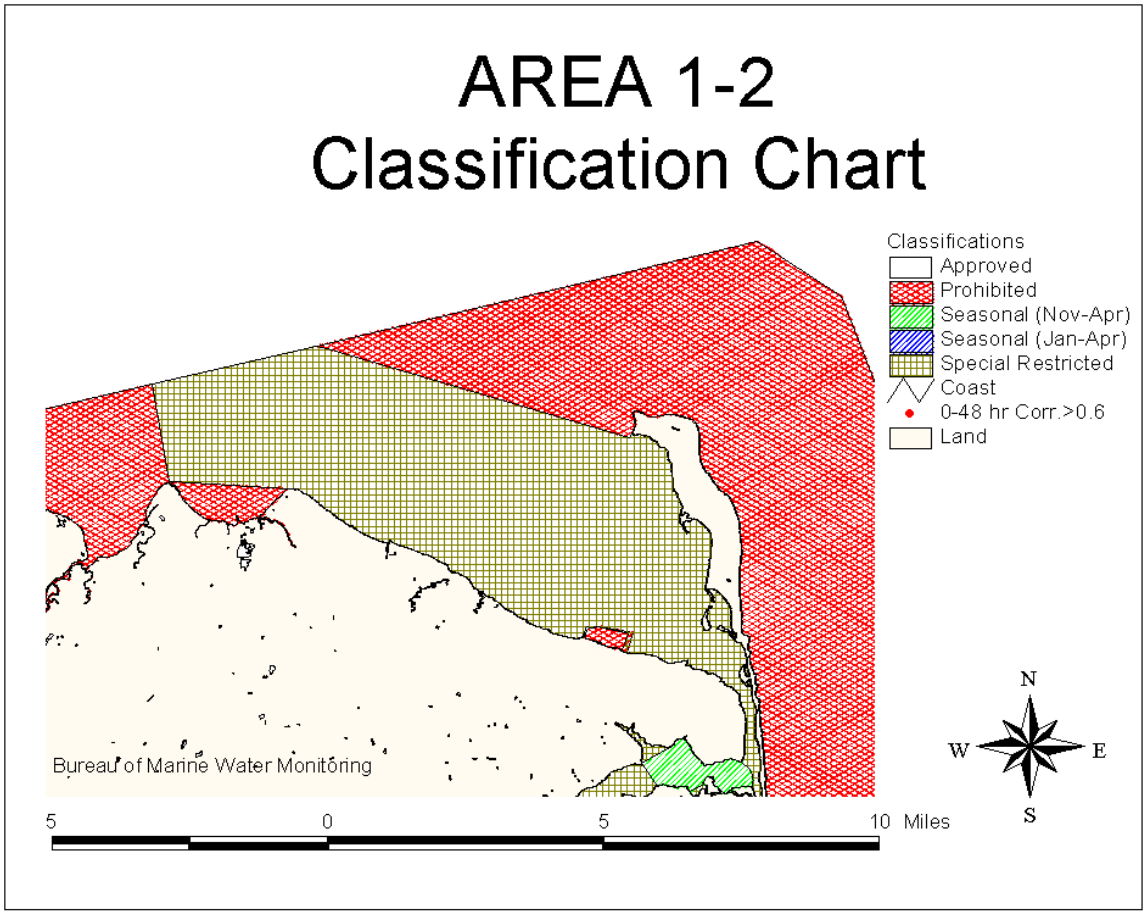


FIGURE 2: LOCATION OF RARITAN / SANDY HOOK BAYS

The waters of Raritan and Sandy Hook Bays are classified as *Special Restricted* or *Prohibited* for the harvest of shellfish. Clams may be harvested for human consumption from *Special Restricted* waters under the Special Permits program. These clams undergo further purification prior to market. Harvest of shellfish for human consumption is not permitted in *Prohibited* waters.

The last Sanitary Survey of this area was completed in 1989 and covered the period through 1986.

FIGURE 3: CURRENT CLASSIFICATION OF SHELLFISH WATERS IN RARITAN / SANDY HOOK BAYS



METHODS

Water sampling was performed in accordance with the Recommended Procedures for the Examination of Seawater and Shellfish, 4th. Edition, American Public health Association, 1970 and the Field Procedures Manual (NJDEP, 1992).

Approximately 700 water samples were collected for total and fecal coliform bacteria between August 24, 1994 and May 8, 1997 and analyzed by the three tube (3 dilution) MPN method according to APHA (1970). Figure 19 shows the Shellfish Growing Water Quality monitoring stations in the Raritan and Sandy Hook Bays. Approximately 36 stations are monitored during each sampling run.

The Interstate Sanitation Commission has collected the winter samples since 1996. Under the National Environmental Performance Partnership System agreement referenced above, the USEPA analyzed samples from two sampling runs: January 29, 1997, and February 6, 1997.

Water quality sampling, shoreline and watershed surveys were conducted in accordance with the NSSP Manual of Operations, Part I, Appendix B (USPHS, 1995) and the NSSP Guide for the Control of Molluscan Shellfish, Model Ordinance, 1997 Revision.

Data management and analysis was accomplished using database applications developed for the Bureau. Mapping of pollution data was performed with the Geographic Information System (GIS:ARCVIEW).

BACTERIOLOGICAL INVESTIGATION AND DATA ANALYSIS

The water quality of each growing area must be evaluated before an area can be classified as *Approved, Seasonally Approved, Special Restricted,* or *Seasonal Special Restricted*. Criteria for bacterial acceptability of shellfish growing waters are provided in the National Shellfish Sanitation Program Model Ordinance, 1997 Revision. Each shellfish producing state is directed to adopt either the total coliform criterion, or the fecal coliform criterion. While New Jersey bases its growing water classifications on the total coliform criterion, it does make corresponding fecal coliform determinations for each sampling station. The fecal coliform data are viewed as adjunct information and is not directly used for classification.

The State Shellfish Control Authority has the option of choosing one of the water monitoring sampling strategies for each growing area. The Adverse Pollution Condition Strategy requires that a minimum of five samples be collected each year under conditions that have historically resulted in elevated coliforms in the particular growing area. The results must be evaluated by adding the individual station sample results to the preexisting bacteriological sampling results to constitute a data set of at least 15 samples for each station. The adverse pollution conditions usually are related to tide, and rainfall, but could be from a point source of pollution or variation could occur during a specific time of the

year. Under this strategy, for *Approved* waters, the total coliform median or geometric mean MPN of the water shall not exceed 70 per 100 ml and not more than 10 percent of the samples exceed an MPN of 330 per 100 ml for the 3-tube decimal dilution test. For *Special Restricted* waters, the total coliform median or geometric mean MPN of the water shall not exceed 700 per 100 ml and not more than 10 percent of the samples exceed an MPN of 3300 per 100 ml for the 3-tube decimal dilution test. Areas to be Approved under the Seasonal classification must be sampled and meet the criterion during the time of the year that it is approved for the harvest of shellfish.

The Systematic Random Sampling strategy requires that a random sampling plan be in place before field sampling begins and can only be used in areas that are not affected by point sources of contamination. A minimum of six samples per station are to be collected each year and added to database to obtain a sample size of 30 for statistical analysis. The bacteriological quality of every sampling station in *Approved* areas shall have a total coliform median or geometric mean MPN not exceeding 70 per 100 ml and the estimated 90th percentile shall not exceed an MPN of 330 per 100 ml. For *Special Restricted* areas, the bacteriological quality shall not exceed a total coliform median or geometric mean MPN of 700 per 100 ml and the estimated 90th percentile shall not exceed an MPN of 3,300 per 100 ml.

The Raritan and Sandy Hook Bays are sampled under the Adverse Pollution Condition of rainfall.

MARINE BIOTOXINS

The Department collects samples at regular intervals throughout the summer to determine the occurrence of marine biotoxins. This data is evaluated weekly by the Bureau of Marine Water Monitoring in accordance with the NSSP requirements. An annual report is compiled by the Bureau of Freshwater and Biological Monitoring.

EVALUATION OF BIOLOGICAL RESOURCES

Raritan and Sandy Hook Bays contain abundant shellfish resources (Figures 4-6). In 1997 an estimated 32 million clams were taken from Raritan and Sandy Hook Bays under the Special Permit Program (combined relay and depuration) worth in excess of 11 million dollars (Joseph, 1998). Table 1 lists the combined relay and depuration harvest, effort, and catch-per- effort data for Raritan and Sandy Hook Bays. Designated harvest areas for the relay and depuration of hard and soft clams in the *Special Restricted* waters of Raritan and Sandy Hook Bays are shown in Figures 7-8.

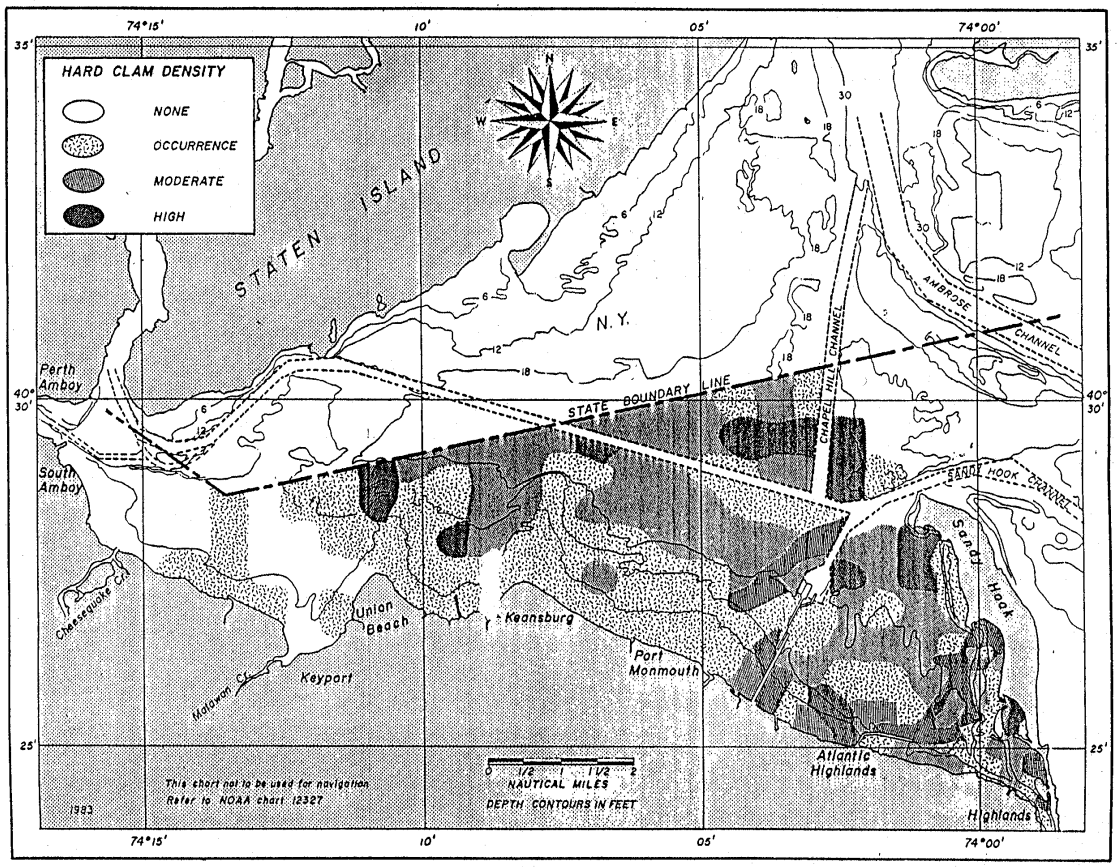


FIGURE 4: HARD CLAM RESOURCES IN RARITAN / SANDY HOOK BAY

FIGURE 5: SOFT CLAM RESOURCES IN RARITAN / SANDY HOOK BAY

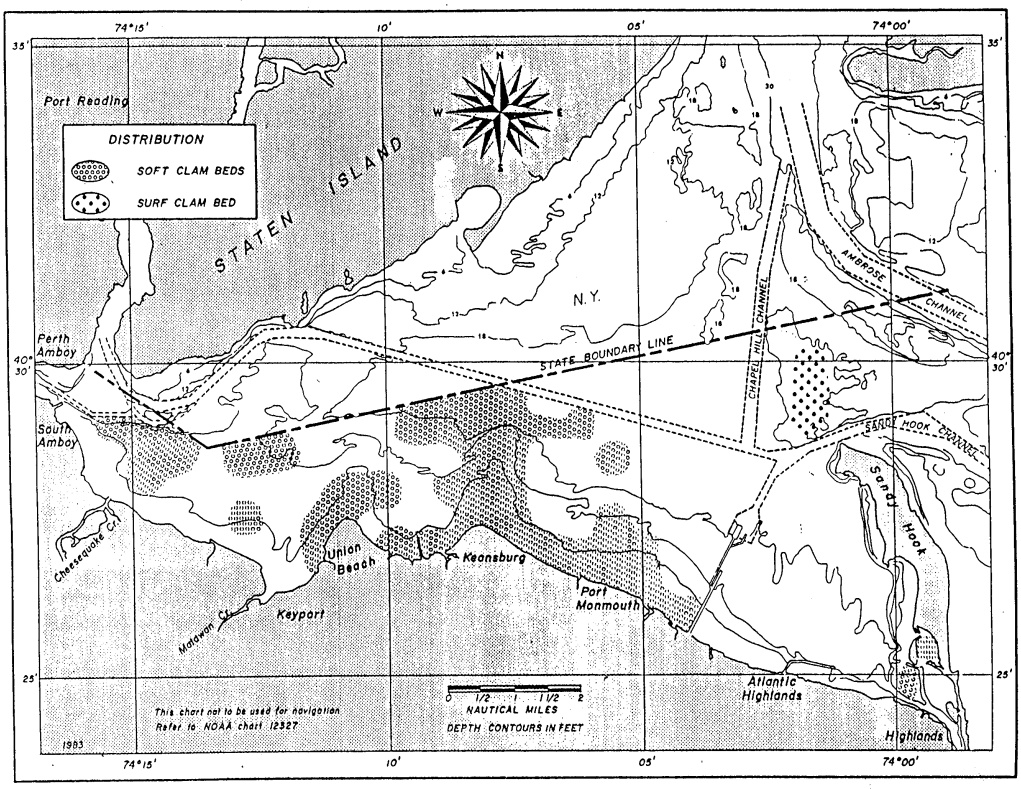
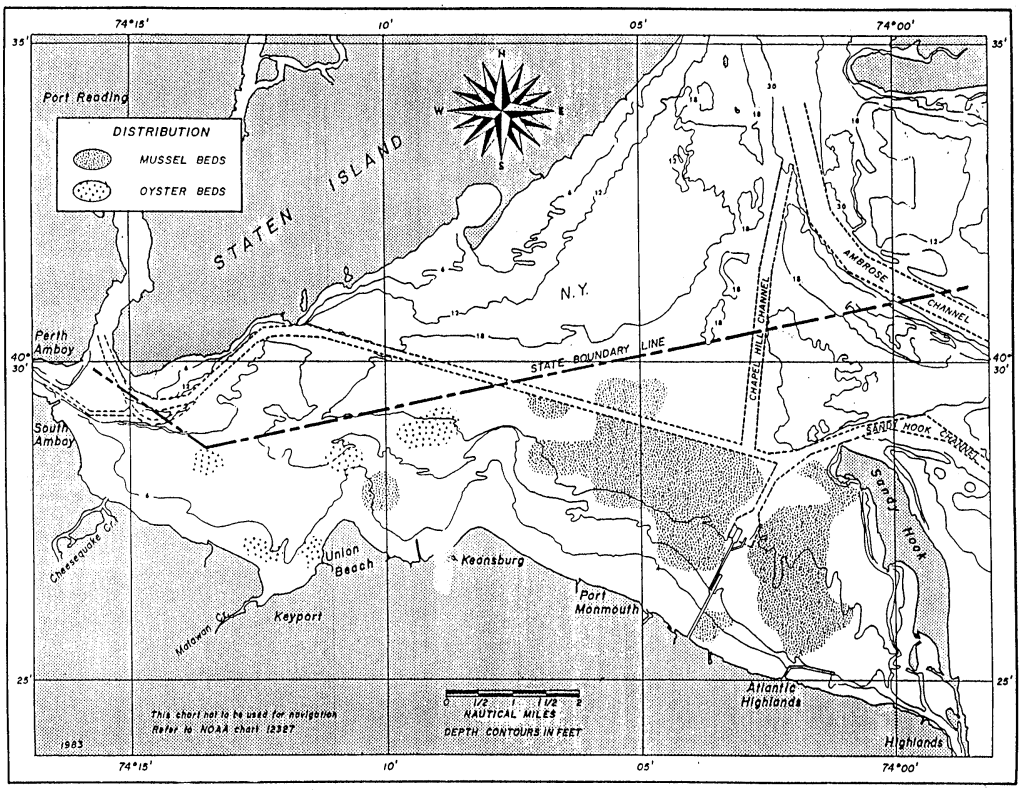


FIGURE 6: MUSSEL AND OYSTER RESOURCES IN RARITAN / SANDY HOOK BAY



SPECIAL PERMITS PROGRAM

Clams harvested from waters classified as Special Restricted must be treated prior to sale for human consumption. Treatment may be through the depuration program, where clams are held in tanks in clean water for a period of time, or the relay program, where clams are places in clean water in Barnegat Bay for a period of time. This process provides sufficient time for the clams to excrete any bacteria that may have adhered to the tissue prior to harvest. The James T. White clam depuration plant is located in Highlands. Another depuration plant, Clean Water Clams, is located to the south of the Highlands Bridge.

The implementation of shellfish resource recovery programs is a cooperative effort of State agencies involved with Shellfish in New Jersey (Osborn, 1993).

The programs include the issuance of special permits to utilize bivalve mollusks harvested from *Special Restricted* waters. The permits contain special conditions relating to the collection, bacterial purging, and subsequent marketing of shellfish taken under the purview of the program and deemed necessary to protect public health.

Requests by the shellfish industry to utilize the extensive shellfish resources from the bay waters of Northern Monmouth County prompted the establishment of a Shellfish Resource Recovery Steering Committee. The committee is made up of representatives from the Department of Environmental Protection and the Department of Health and Senior Services, who have the regulatory responsibilities for administering the shellfish resource programs.

FIGURE 7: DESIGNATED HARVESTING AREAS IN RARITAN BAY

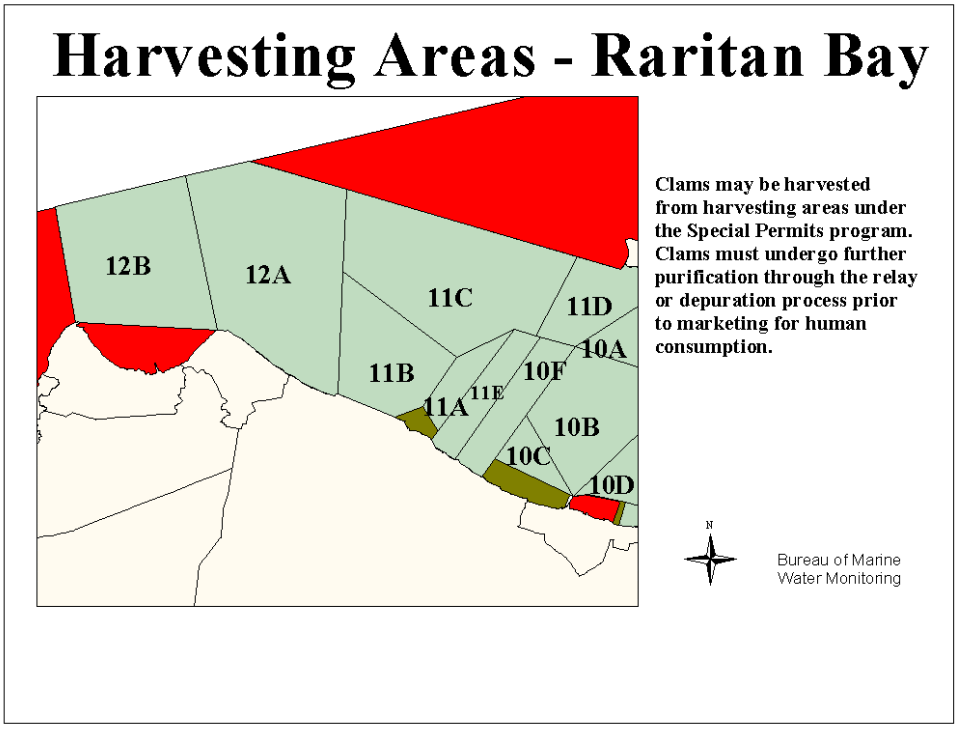


FIGURE 8: DESIGNATED HARVESTING AREAS IN SANDY HOOK BAY

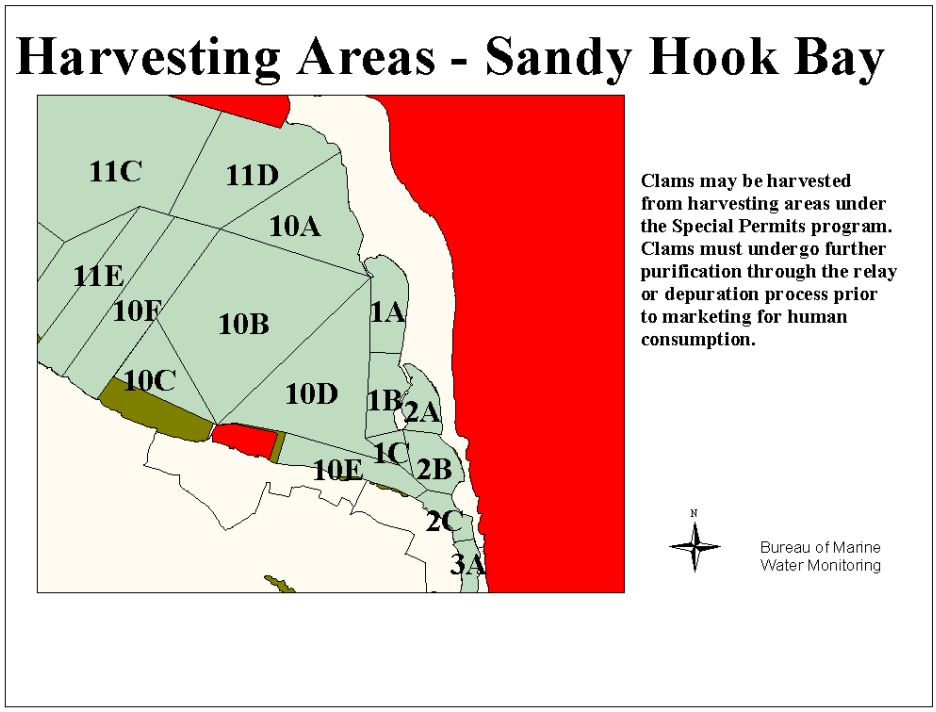


TABLE 1: COMBINED RELAY AND DEPURATION HARVEST, EFFORT, AND CATCH PER EFFORT

YEAR	AREA	HARVEST (# of clams)	EFFORT (Man days)	CATCH/EFFORT (Clams/man/day)
1997	Raritan Bay	15,469,663	5,444.5	6,049
	Sandy Hook Bay	16,395,934	6,191.0	4,882
1996	Raritan Bay	15,447,631	5,639.7	5,014
	Sandy Hook Bay	15,371,153	6,154.0	4,105
1995	Raritan Bay	3,624,564	1,290.0	5,230
	Sandy Hook Bay	18,781,304	8,581.0	4,186
1994	Raritan Bay	303,952	115.0	2,643
	Sandy Hook Bay	4,285,650	2,011.5	2,131

Source: New Jersey Division of Fish Game and Wildlife, Bureau of Shellfisheries, Nacote Creek Field Station.

Land Use

The shoreline is well developed with residential, business, and industrial areas. There are a few forested areas remaining and some inland areas still devoted to agriculture. The Borough of Highlands has the highest coastal point on the East Coast (from Maine to Florida) with an elevation in excess of 260 feet above sea level. Most of Sandy Hook remains undeveloped as a National Park with an active Coast Guard base at the northern end.

There are 5 municipalities in Middlesex County and 9 municipalities in Monmouth County that adjoin the Raritan / Sandy Hook Bay area. The area is relatively densely populated.

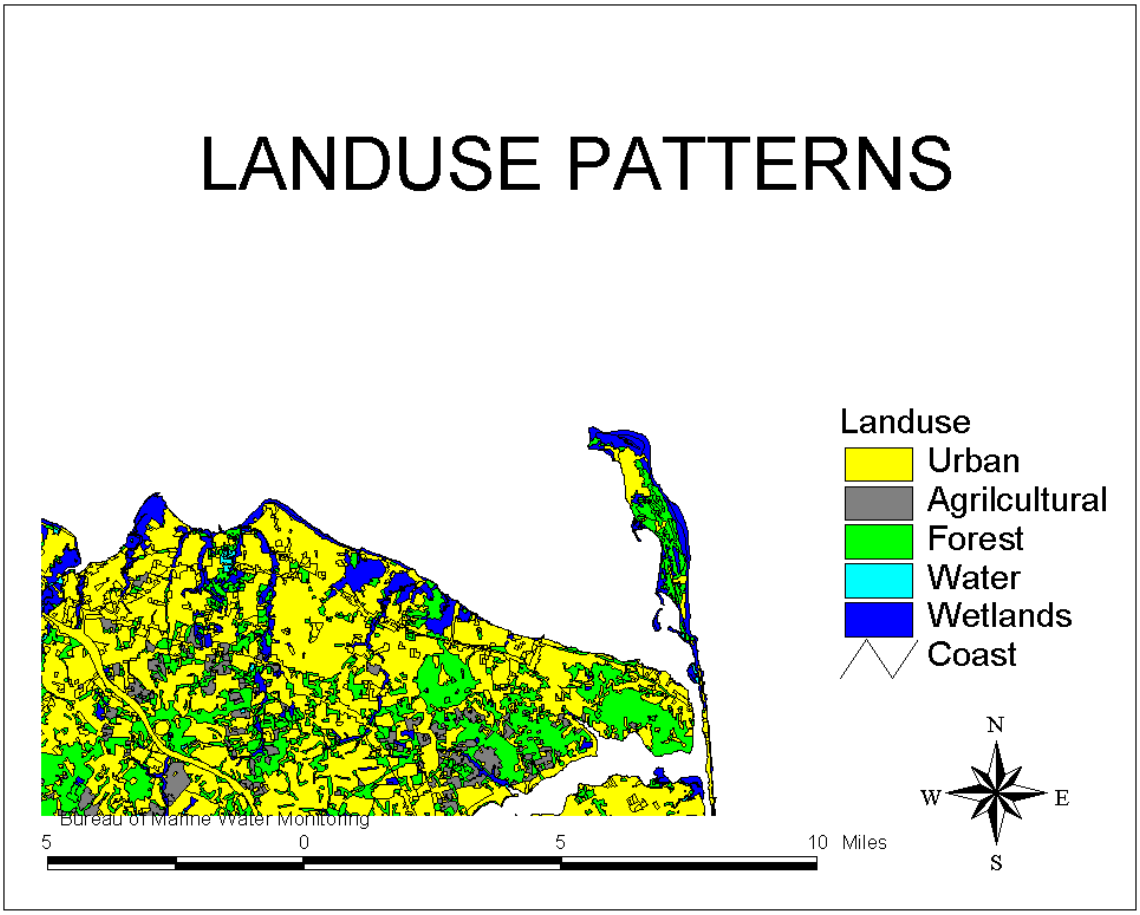


FIGURE 9: LAND USE PATTERNS

TABLE 2 : MUNICIPAL STATISTICS

Municipality	1990 Census	
	Population	Density
Middlesex County		
Woodbridge	93086	3802
Perth Amboy	41976	7033
Sayreville	34986	1866
South Amboy	7863	3026
Old Bridge	56475	1376
Monmouth County		
Union Beach	6156	3257
Keansburg	11069	9465
Aberdeen Twp	16720	3257
Hazlet	21976	3820
Keyport	7586	5181
Middletown	68183	1691
Atlantic Highlands	4629	3788
Highlands	4849	6696
Sea Bright	1693	1664

CHANGES SINCE THE LAST SURVEY

Changes since the last survey include:

- Upgrade and expansion of both Bayshore Regional Sewerage Authority and Middletown Sewerage Authority. Both of these facilities convey their waste to the Monmouth County Bayshore Outfall Authority for eventual discharge into the Atlantic Ocean.
- Upgrade of the sewerage facilities at the National Recreation Area at Sandy Hook. The waste generated at the facility is discharged to ground water.
- Significant problems with the ability of the Monmouth County Bayshore Outfall Authority to convey the amount of waste generated to the Atlantic Ocean outfall site. Some of these problems have been related to the volume of waste generated, particularly in wet weather. Other

problems have been related to failure of the pipe integrity and subsequent leakages.

- Increases in the amount of shellfish resource available for harvest, measured both in terms of overall harvest and in catch per effort.
- An overall trend toward improving water quality in the bay. This trend has not resulted in upgrading the classification of the water.

IDENTIFICATION AND EVALUATION OF SOURCES

Permitted Point Sources

The Raritan Bay estuary receives large amounts of municipal and industrial wastes both directly and through the tributary waters of this area. These wastes include heavy metals, petroleum hydrocarbons, pesticides and volatile organics (Scro, 1992).

The *Special Restricted* shellfish waters do not receive any permitted discharges from wastewater treatment plants. However, Middlesex County Utilities Authority has a permitted 160 MGD outfall located in the *Prohibited* waters of Raritan Bay approximately 3 miles west of the *Special Restricted* waters. The peak flow rates from this outfall can exceed 200 MGD. The potential pathogenic impact of the discharge was evaluated in 1997 (Sobsey, 1997). Monmouth County Bayshore Outfall Authority operates an interceptor that conveys waste treated at Bayshore Regional Sewerage Authority and Middletown Township Sewerage Authority to an outfall located in the Atlantic Ocean approximately 1 mile offshore.

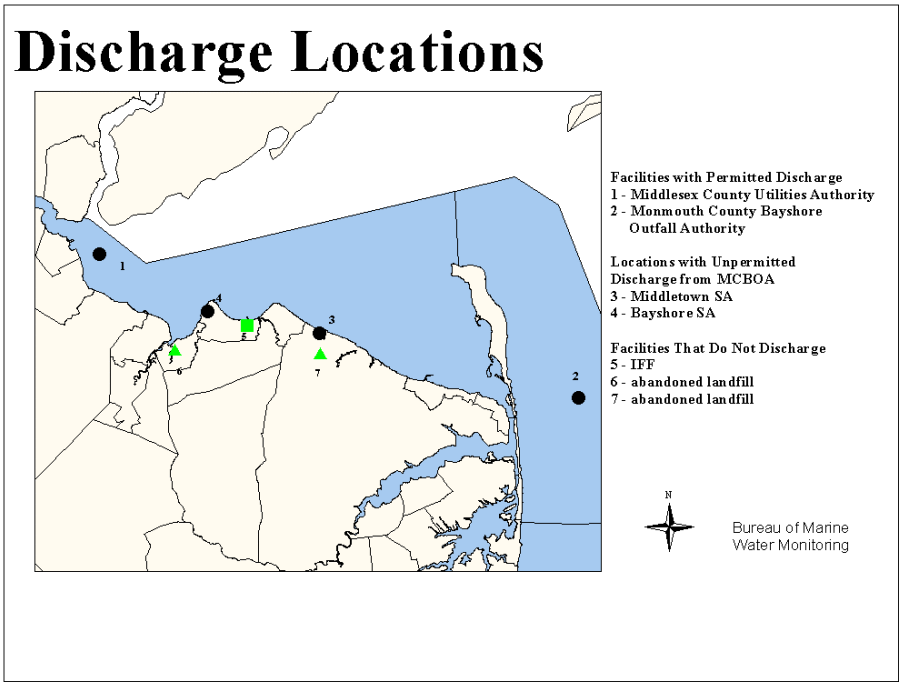


FIGURE 10: DISCHARGES TO SURFACE WATER

Middlesex County Utilities Authority

The Middlesex County facility discharges from an H-shaped diffuser in the western area of Raritan Bay. The discharge rate is variable, with high flows during and after precipitation events. The permitted flow is 160 MGD; flows in excess of 200 MGD have frequently been reported. The Utility also discharges during precipitation events from a supplemental outfall located in the Raritan River.

It should be noted that Middlesex County uses chlorination to disinfect. Therefore, viral contamination would be unaffected by treatment processes. In addition, The facility discharges numerous heavy metals in quantities sufficient to cause exceedances of the Surface Water Quality Standards. As a consequence, the current *Prohibited* area extends beyond the boundaries of the area shown in Figure 12. This report recommends further sampling in the western end of Raritan Bay for toxicants in shellfish tissue as well as viral contamination of the water column.

Monmouth County Bayshore Outfall Authority

MCBOA (a non-profit organization) operates the pipeline system to transmit secondary treated effluent from treatment plants in Union Beach (Bayshore Regional Sewage Authority) and Belford (Middletown Sewage Authority) for disposal into the Atlantic Ocean. The pipeline serves 12 municipalities. The communities include Atlantic Highlands, Highlands, Middletown, Holmdel, part of Marlboro and Colts Neck, Union Beach, Hazlet, Keansburg, Matawan Borough, Matawan Township and Keyport.

The pipeline is a force main designed in 1970 to meet the sewage disposal needs of the region to the year 2000 with a design flow for 28 MGD. It is constructed of reinforced concrete pipe and steel. Pump stations located at Union Beach and Belford have large retention basins used to attenuate peak flows and even out daily flow variations. Numerous inspection chambers are provided for adequate maintenance. Emergency pumps and electrical generators are maintained at each pump station. The pipeline is 74,000 feet long and follows the former rail bed of the Central Railroad of New Jersey, extending from Union Beach to a point 4,000 feet into the Atlantic Ocean off Sandy Hook. It passes under Sandy Hook Bay just north of the Highlands Bridge (Figure 11).

In 1973 the Middletown plant began pumping effluent to the line at a rate of five MGD. In 1974 the Union Beach plant began pumping to the line at a rate of two MGD. Both facilities were recently upgraded and expanded to accommodate additional tie-ins. Each presently pumps at the rate of approximately 15-17 MGD under dry weather conditions.

Since the last report in 1996, the pipeline has experienced numerous difficulties resulting in the discharge of treated and partially treated effluent to the coastal waters of Raritan and Sandy Hook Bays.

These discharges have resulted in numerous suspensions of harvest in the shellfish waters of the area.

A major rehabilitation of the MCBOA outfall line is tentatively scheduled to begin January 11, 1999. The Authority has 30 days to complete all work on the line. During the rehabilitation period, treated effluent will be discharged at the treatment facilities located at Union Beach and Belford. Treated effluent remaining in the line at the start of the construction period will be discharged at locations along the line's path.

During the period of discharge harvest in the shellfish waters will be suspended until repairs are completed and adequate flushing of the bay waters has taken place. The New Jersey Department of Environmental Protection will monitor the progress of the rehabilitation work.

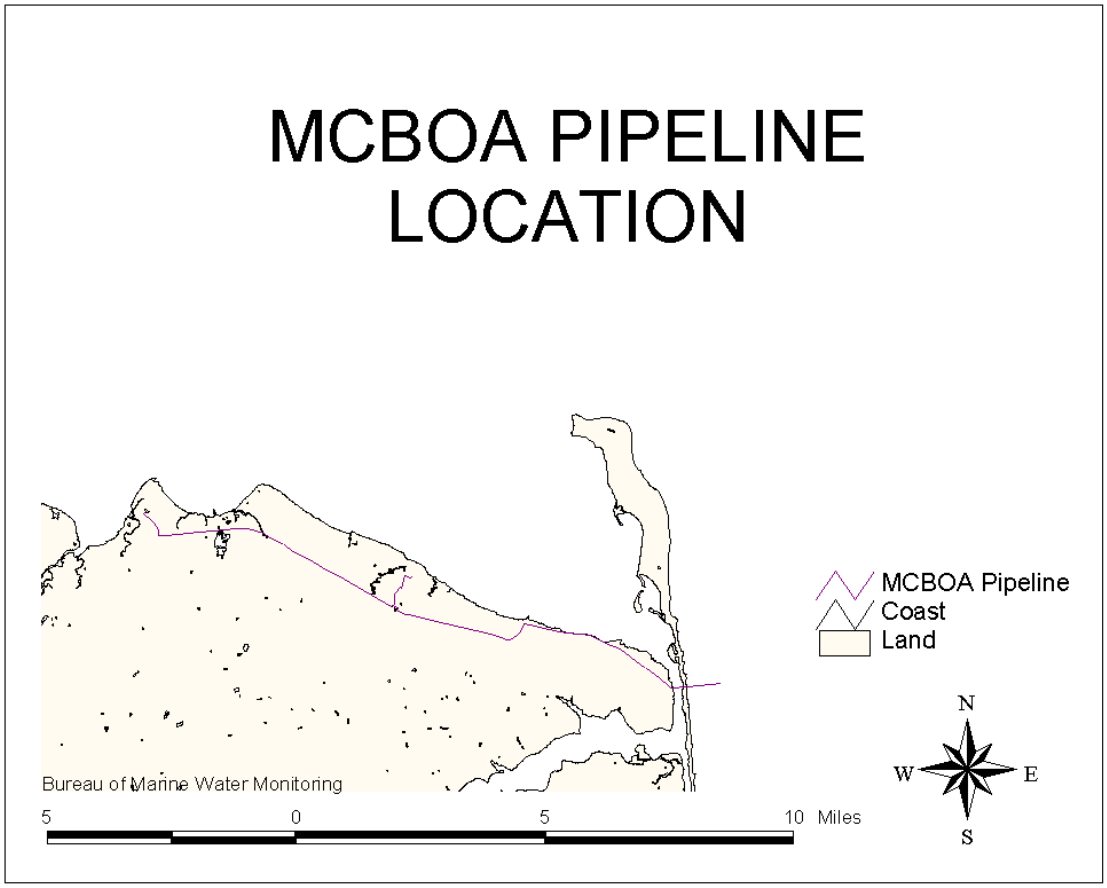


FIGURE 11: MONMOUTH COUNTY BAYSHORE OUTFALL AUTHORITY

TABLE 3: UNPERMITTED DISCHARGES FROM THE MONMOUTH COUNTY BAYSHORE OUTFALL AUTHORITY

DATE	LOCATION	GALLONAGE (MG)	HARVEST SUSPENDED
11/13/97	Off of Route 36, Port Monmouth to Raritan Bay	0.6	YES
11/13/97	BRSA manhole to Raritan Bay	1.25	YES
12/09/97	Manhole on Jersey Ave., Union Beach to Raritan Bay	0.325	YES
12/09/97	BRSA manhole to Raritan Bay	1.1	YES
1/11/98	Manhole off Ocean Ave.,Middletown to ground	0.0005	NO
1/14/98	Manhole off Bray Ave., Port Monmouth to ground	0.0006	NO
1/23-24/98	BRSA manhole to Raritan Bay	2.1	NO (see footnote)
2/10-11/98	Blowoff to Compton's Creek	0.309	YES
2/11-12/98	BRSA manhole to Raritan Bay	15.0-20.0	YES
2/24-25/98	BRSA manhole to Raritan Bay	3.0	YES
3/09/98	BRSA manhole to Raritan Bay	3.0	YES
5/09-13/98	BRSA manhole to Raritan Bay	14.0	YES
6/14-15/98	BRSA manhole to Raritan Bay	3.0	YES
7/20-21/98	Manhole off Jersey Ave.	0.1	YES
07/20-22/98	BRSA manhole to Raritan Bay	7.9	YES

Note: SOURCE: NJDEP BUREAU OF CENTRAL ENFORCEMENT, Anthony Rotundo.
The discharge that occurred on January 23 and 24, 1998 did not result in the suspension of harvest. Due to an unexplained communication problem, the Bureau of Marine Water Monitoring was not aware of the discharge until several days after the discharge had ceased.

Facilities at Sandy Hook

The National Park Service operates a newly upgraded wastewater treatment facility on park property. The plant handles approximately 150,000 gallons per day. The plant provides tertiary treatment with treated effluent discharged to infiltration beds. There are no surface water discharges. All buildings on the National Park property are reported as being connected to the sanitary sewer line. A few remote beach areas still use portable toilets during the summer months.

Sanitary wastewater generated at the Coast Guard Station on Sandy Hook is handled by the National Park Service's treatment facility. The Park Service also services the collection lines. Coast Guard vessels have portable toilets or holding tanks. There are no wastewater discharges associated with waterfront activities.

Facilities at the Earle Naval Station

The naval docking facilities at the Earle Naval Pier extend approximately 2 miles into Sandy Hook Bay. There are no discharges from the pier operation or along the adjacent shoreline. Sanitary wastes are pumped from holding tanks on docked ships to a pipeline connected to the Middletown Township facility at Belford. Bilge water from docked ships is pumped to railroad tank cars and transported to an oil-water separator. Processed wastewater then goes to the sanitary line.

International Flavor and Fragrances Facility

The International Flavor and Fragrances plant located between Union Beach and Keansburg, along the eastern side of East Creek is no longer operated as a manufacturing facility. The company now uses it as a warehouse. The small amount of wastewater now generated goes directly to the sanitary sewer line. Shellfish waters at the mouth of East Creek are classified as *Prohibited* waters.

Disinfection Policies for Domestic Waste

In an effort to enhance shellfishing and upgrade general water quality in the Raritan Bay the Interstate Sanitation Commission (ISC) amended its Water Quality Regulations (Section 205(b)) to require that beginning July 1, 1986, New Jersey and New York City municipalities practice effluent disinfection on a year-round basis. Previously, disinfection had been required only during the summer months. Discharge permits for municipal and industrial facilities were modified to reflect this change.

In September 1988, the Interstate Sanitation Commission released a report entitled 1986/1987 Intensive Water Quality Surveys within New York/New Jersey Metropolitan Area. Total and fecal coliform geometric means were compared in samples collected during the periods of seasonal disinfection (March of 1984, 1985 and 1986) and year-round disinfection (November 1986 and February 1987) in Raritan Bay. Coliform concentrations decreased substantially since the Commission's year-round disinfection requirement went into effect. The study also showed that combined sewer overflows (CSO's) which are triggered by wet weather conditions are a "primary factor for elevated coliform concentrations in the waters within the study area" (Scro, 1992).

Buffers around outfalls

The National Shellfish Sanitation Program requires establishment of *Prohibited* areas adjacent to outfalls from domestic sewage treatment facilities. The *Prohibited* area ensures that pathogens will not contaminate the resource used for human consumption. The size of the *Prohibited* buffer zone must consider the following characteristics:

- Pollution Conditions
  - Flow rate, treatment facility performance, location of the shellfish resource
- Dispersion, dilution, and time of travel
  - Current velocity and net transport velocity; volume of water; depth of receiving water; direction of travel; stratification; location of discharge; tidal characteristics; receiving water geometry
- Pathogen die-off rate
- Bacteriological quality required in adjacent waters
- Adjacent harvest use classifications
- Identifiable landmarks

These factors account for the presence of contaminants in the effluent, the water quality that much be maintained to protect human health, and the relative dispersion available in the vicinity of the outfall.

There is a permitted discharge from Middlesex County Utilities Authority located at the western end of Raritan Bay. In addition, the Monmouth County Bayshore Outfall Authority has discharged from overflow points in Belford, Union Beach, and at several other points along the interceptor without a permit. These discharges, resulting from flows in excess of the capacity of the interceptor and/or malfunctions and leaks from manholes, are considered unpermitted discharges. A rehabilitation project on the interceptor is scheduled for January 1999.

Contaminants

Effluent from wastewater treatment facilities contains a variety of contaminants. Historically, the emphasis of the shellfish program has focussed on bacteriological contamination. Indicator organisms (usually coliform bacteria) are used to assess the likelihood of pathogen contamination. While these indicator organisms are not in themselves pathogenic, or disease-producing, they are found in human waste in similar numbers to organisms that can cause disease. Disinfection processes such as chlorination kill these bacteria.

Wastewater treatment facility effluent may also include viral particles. Viruses are usually not killed by chlorination. Effluent may also contain various toxicants, such as heavy metals or other contaminants. While some of these toxicants may be partially removed by conventional treatment, other contaminants remain in the effluent discharged to the receiving water.

Size of the buffer zone

The level of treatment and the specific treatment processes provided by the wastewater facility affect the size of the *Prohibited* zone established in the vicinity of the outfall. If disinfection is provided by chlorination, the size is adjusted to account for:

- The reliability record of the particular facility based on data submitted by the facility, and
- The likelihood of viral contamination, which is unaffected by chlorination.

The *Prohibited* area is also adjusted to allow for dispersion of contaminated water in the event that the disinfection process at the facility becomes inoperable. Thus the area could be adjusted based on factors such as installation of alarm systems and/or round-the-clock staffing at the facility.

Middlesex County Utilities Authority

The Middlesex County facility discharges from an H-shaped diffuser in the western area of Raritan Bay. (See Figure 12 for location.) The discharge rate is variable, with high flows during and after precipitation events. The permitted flow is 160 MGD; flows in excess of 200 MGD have frequently been reported. The Utility also discharges during precipitation events from a supplemental outfall located in the Raritan River.

In 1989 the Utilities Authority completed an effluent plume study as a condition of the NJPDES permit issued to the facility. The study consisted of a dye study and computer modeling. Based on that study, the effluent is rapidly diluted by a factor of approximately 15 due to buoyant mixing at the outfall location. Subsequent to that initial dilution, the plume moves to the southeast in the dominant ebb-tide current with minimal additional dilution due to dispersion. Since the primary ebb current then moves toward the northeast, it appears that the effluent plume moves primarily in the vicinity of the major shipping channel where the water is deeper and the current is stronger. However, as can be seen from the hydrographic information (see Figure 18), the circulation in Raritan Bay is not straightforward and the concomitant mixing and dilution of the effluent is accordingly complex.

The study completed by Middlesex County Utilities Authority extended only for a short distance beyond the outfall. Figure 12 shows the area of the study and the best estimate of the Bureau of Marine Water Monitoring of the area impacted by the Middlesex County effluent plume.

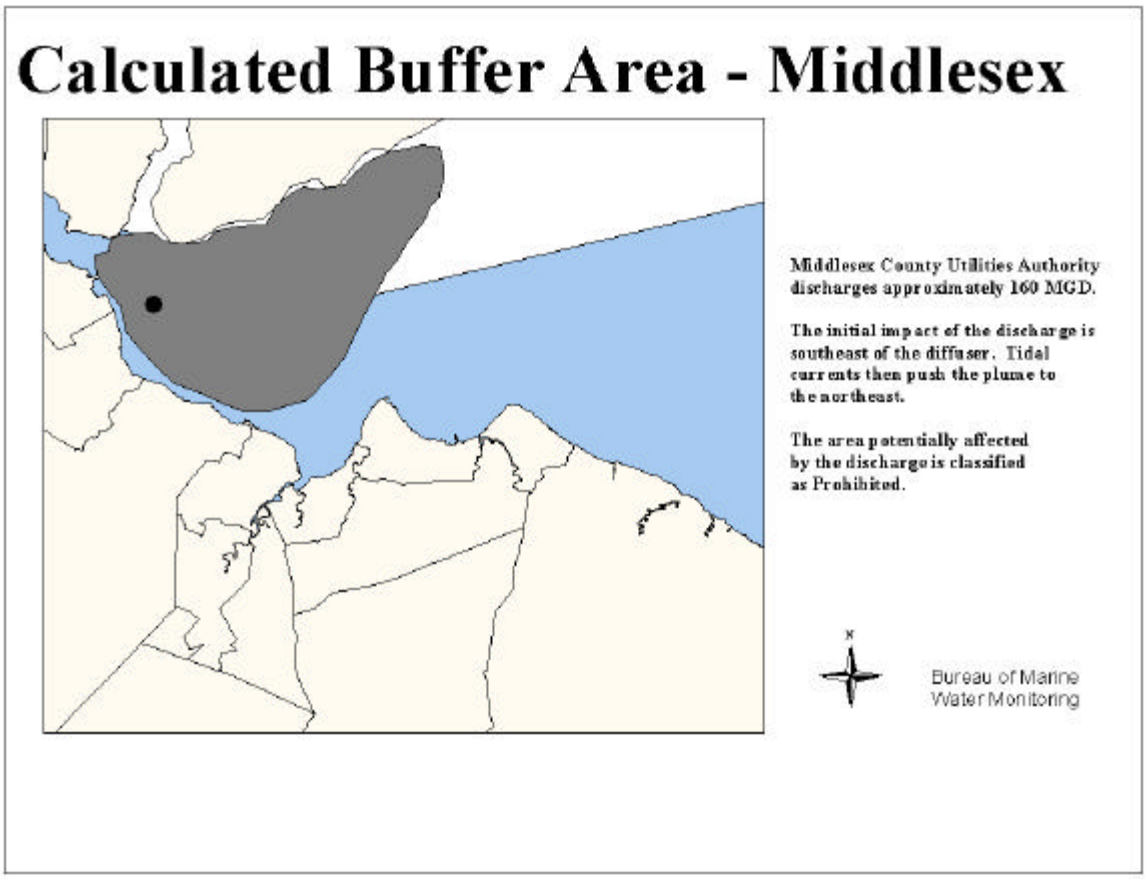


FIGURE 12: BUFFER ZONE SURROUNDING MIDDLESEX COUNTY UTILITIES AUTHORITY

It should be noted that Middlesex County uses chlorination to disinfect. Therefore, viral contamination would be unaffected by treatment processes. In addition, The facility discharges numerous heavy metals in quantities sufficient to cause exceedances of the Surface Water Quality Standards. As a consequence, the current *Prohibited* area extends beyond the boundaries of the area shown. This report recommends further sampling in the western end of Raritan Bay for toxicants as well as viral contamination.

Monmouth County Bayshore Outfall Authority

Domestic waste treated at the Bayshore Utilities Authority in Union Beach and at the Middletown Sewerage Authority in Belford is discharged to the Monmouth County Bayshore Outfall Authority and then conveyed to a permitted outfall in the Atlantic Ocean. The permitted outfall is located approximately 1 mile offshore. The interceptor owned by the Outfall Authority was constructed approximately 20 years ago.

There have been numerous incidents in the last few years when leaks and other unpermitted discharges have resulted from a lack of pumping capacity and/or

leaks or breaks in the interceptor. Each time such a discharge occurs, shellfish beds in the vicinity of the discharge are closed to harvesting. The Authority has proposed a repair schedule that would result in a continuous discharge during the repair period at two locations as shown in Figure 13.

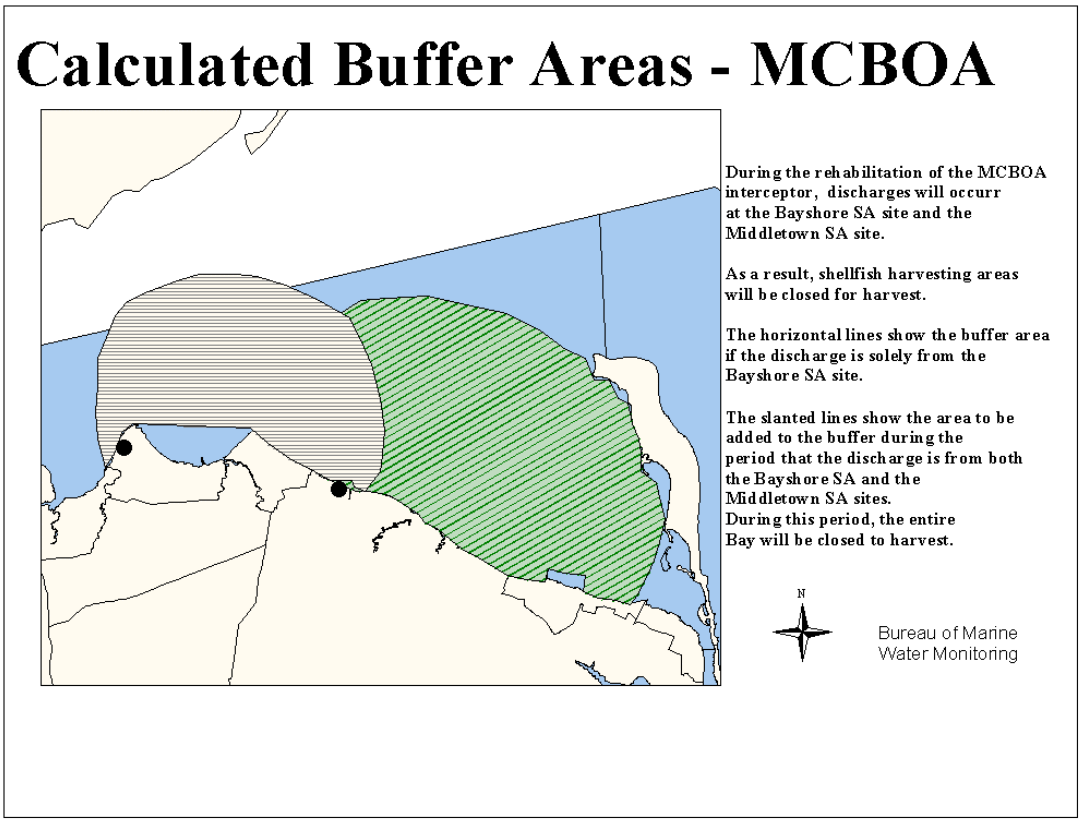
Each of these temporary discharge locations would be an unsubmerged discharge. At the Union Beach site, the discharge would be from a manhole located in the wetlands adjacent to the Bayshore treatment facility. At the Belford site, the discharge would be from a pipe located in the bank of the tidal stream. Approximately 10 MGD would be discharged from each location. No dye studies have been completed to demonstrate the likely plume characteristics.

The depth of the receiving water ranges from approximately 1 – 15 feet in the potentially impacted area. No information was available on toxic constituents in the effluent. *Prohibited* areas were calculated for each of the proposed discharge locations using

- The known variability of effluent bacteriological quality (based on effluent data submitted by the facility as a part of Discharge Monitoring Reports),
- The volume of effluent,
- Prevailing wind direction and velocity during the time of the anticipated discharge,
- The depth of the receiving water, and
- The tidal currents.

The calculated areas to be closed to harvest are shown below. For the period when effluent is discharged from the Union Beach location, the harvesting will be suspended in areas 12A and 12B. For the period when effluent is discharged at both Union Beach and Belford, harvesting will be suspended in all areas of Raritan and Sandy Hook Bays.

FIGURE 13: BUFFER ZONES SURROUNDING MCBOA DISCHARGES AT UNION BEACH AND BELFORD



Storm Water Discharge

Numerous storm water outfalls have been mapped in this area (Figure 12). Most of the storm water discharges to creeks. Some discharge directly into the Raritan and Sandy Hook Bays. The Monmouth County Health Department (MCHD) has not reported any identified bacteriological problem associated with these discharges. Although storm water runoff influences water quality in Raritan and Sandy Hook Bays, the estuaries (particularly Raritan Bay) are also influenced by numerous other waterways and discharges from outside the growing area. Raritan Bay can also be influenced by Sandy Hook Bay since the net flow is outward into the Raritan Bay and Lower Bay.

Street flooding in the communities of Keansburg, Union Beach, Middletown and Hazlet is alleviated by the Bayshore Floodgate. This floodgate is located at the junction of Thorns Creek and Waackaack Creek. This flood control project consists of a 50 ton dam that can be closed to prevent high tides of the Raritan Bay from flooding low-lying areas. Three to four miles of earthen berms were constructed to work in conjunction with the floodgate. Four diesel pumps each capable of 200 gallons per minute can be used to lower water levels behind the dam. The communities

mentioned above all divert their stormwater discharges into the two creeks. The facility is operated by the New Jersey Department of Environmental Protection. Approximately 6 people are employed there. The facility uses a septic system to handle their wastewater. No problems are reported with the operation of this septic system. Shellfish waters at the mouth of the Waackaack Creek are classified as Prohibited waters.

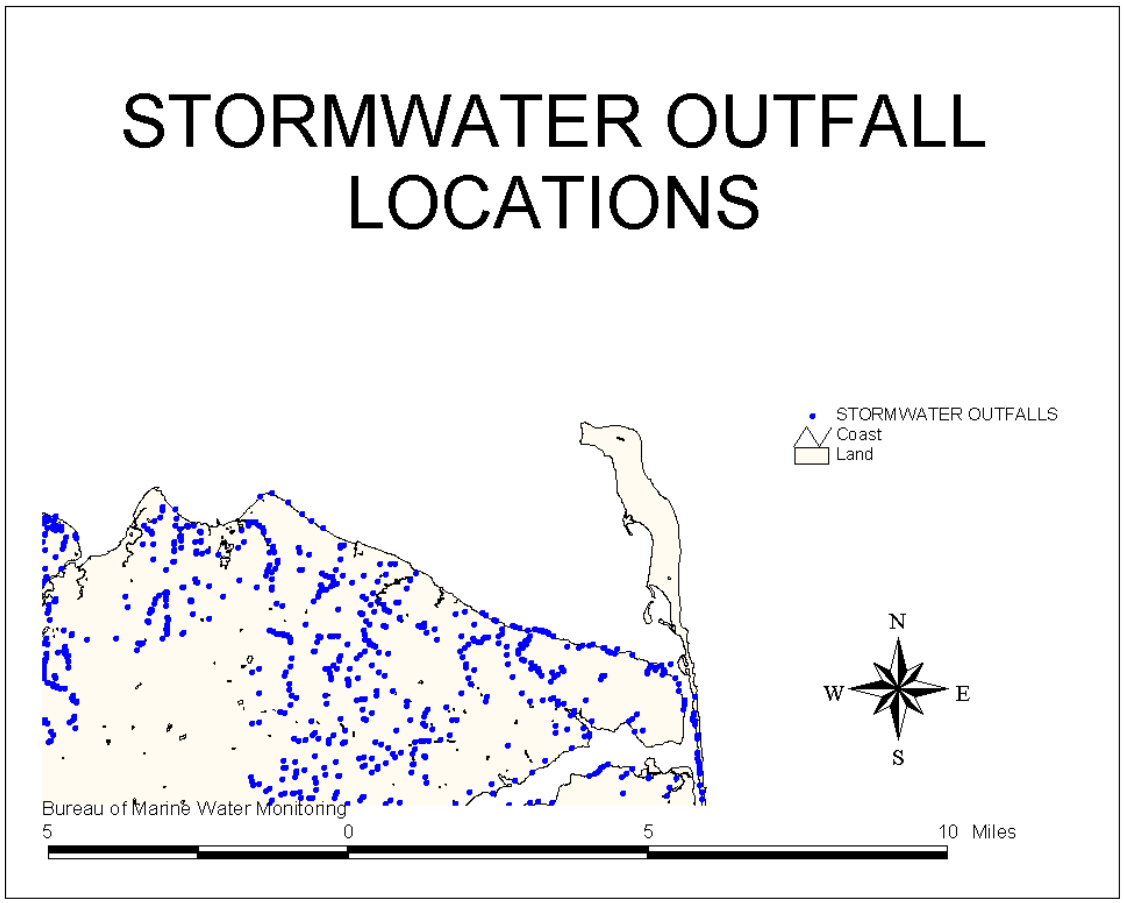


FIGURE 14: STORM WATER OUTFALL LOCATIONS

Input from Surface Water Drainage

There are 11 creeks of concern that are located between Conaskonk Point and Highlands that discharge directly to the *Special Restricted* waters of Raritan / Sandy Hook Bay. From west to east the creeks are named as follows; Chingarora Creek (ditched extension), Flat Creek (Union Beach), East Creek, Thorns Creek, Waackaack Creek, un-named creek (Keansburg), Pews Creek (Ideal Beach), Compton Creek (Belford Harbor), Ware Creek (Earle Pier), Wagner Creek (Leonardo), Many Mind Creek (Atlantic Highlands). All of these streams can be considered as minor tributaries to the bay waters. Each of

them receives stormwater runoff from areas located to the north and south of Route 36.

The Bureau of Marine Water Monitoring does not currently sample the bay waters near the mouths of these creeks. These creeks should be sampled by the Bureau of Marine Water Monitoring because of their potential impact on the shellfish waters.

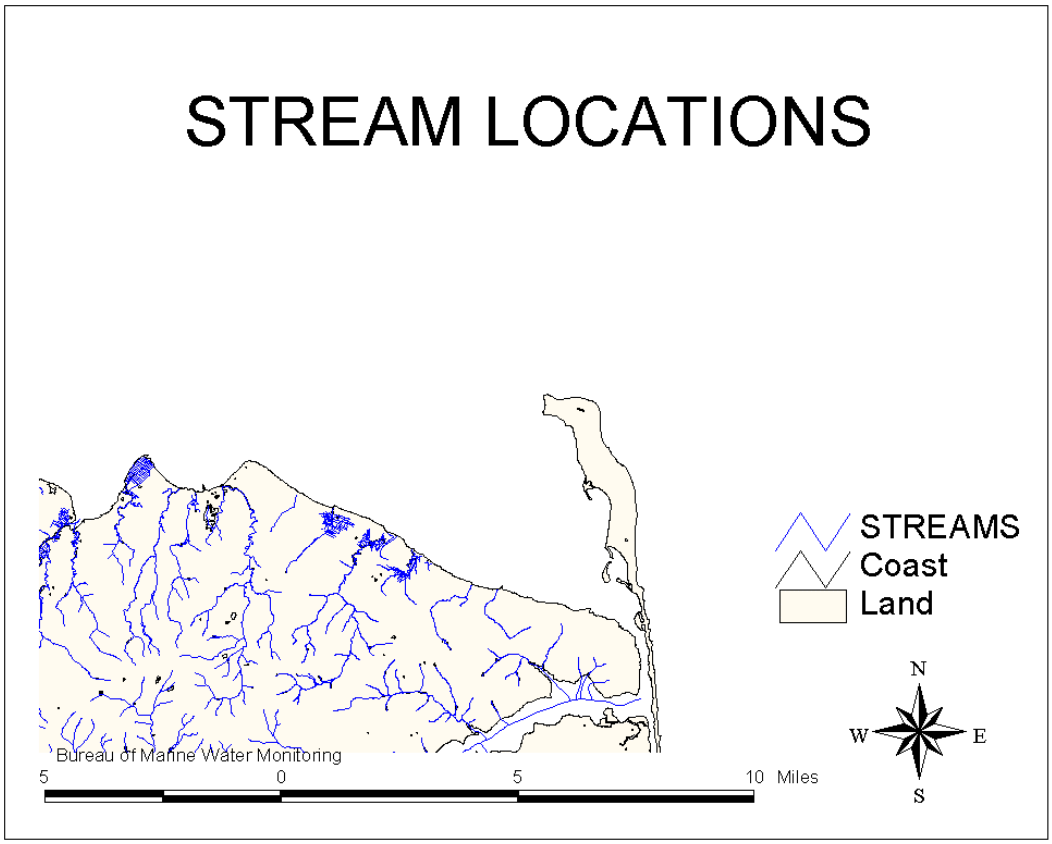


FIGURE 15: STREAMS DRAINING INTO RARITAN / SANDY HOOK BAYS

Marinas

Marina facilities have the potential to affect the suitability of shellfish growing areas for the harvest of shellfish. The biological and chemical contamination associated with marina facilities may be of public health significance. New Jersey defines a marina as "any structure (docks, piers, bulkheads, floating docks, etc.) that supports five or more boats, built on or near the water, which is utilized for docking, storing, or otherwise mooring vessels and usually but not necessarily provides services to vessels such as repairing, fueling, security or other related activities" and designates the confines of the marina as *Prohibited* for the harvest of shellfish. Adjacent waters are classified using a dilution analysis formula.

It is recognized by the National Shellfish Sanitation Program, Manual of

Operations, Part1, Section C-9, that there are significant regional differences in all factors that affect marina pollutant loading. The manual therefore allows each state latitude in applying specified occupancy and discharge rates. The NSSP guidelines assume the worst case scenario for each factor.

EQUATION 1 :MARINA BUFFER EQUATION.

(adapted from FDA. 1989; State of Delaware; State of Virginia):

$$BufferRadius(ft) = \sqrt{\frac{2x10^{9}(FC/person/day)x2(person/boat)x[(.25slips \geq 24') + (0.065 \times slips < 24')]x2}{140000(FC/M^{3})xdepth(ft)x0.3048(M/ft)xpx2(tides/day)}} x3.28(ft/M)$$

Explanation of terms in equation:

Fecal coliform per person per day:	2 x 10^{9}
Number of people per boat:	2
For slips able to accommodate boats > 24 feet (combination of factors yields multiplier of 0.25):	
Number of slips occupied:	50%
Number of boats occupied:	50%
For boats < 24':	6.5% discharge waste
Angle of shoreline:	180^{o}, which results in factor of 2
Number of tides per day:	2
Depth in meters:	depth in feet x conversion factor
Water quality to be achieved:	140000 FC/$meter^{3}$
Convert meters to feet:	3.28

Marina buffer zones may be calculated using the formula above, or may be determined using a dilution analysis computer program developed by the State of Virginia and the USFDA. The computer program is used for complex configurations where the formula is unlikely to provide the needed accuracy.

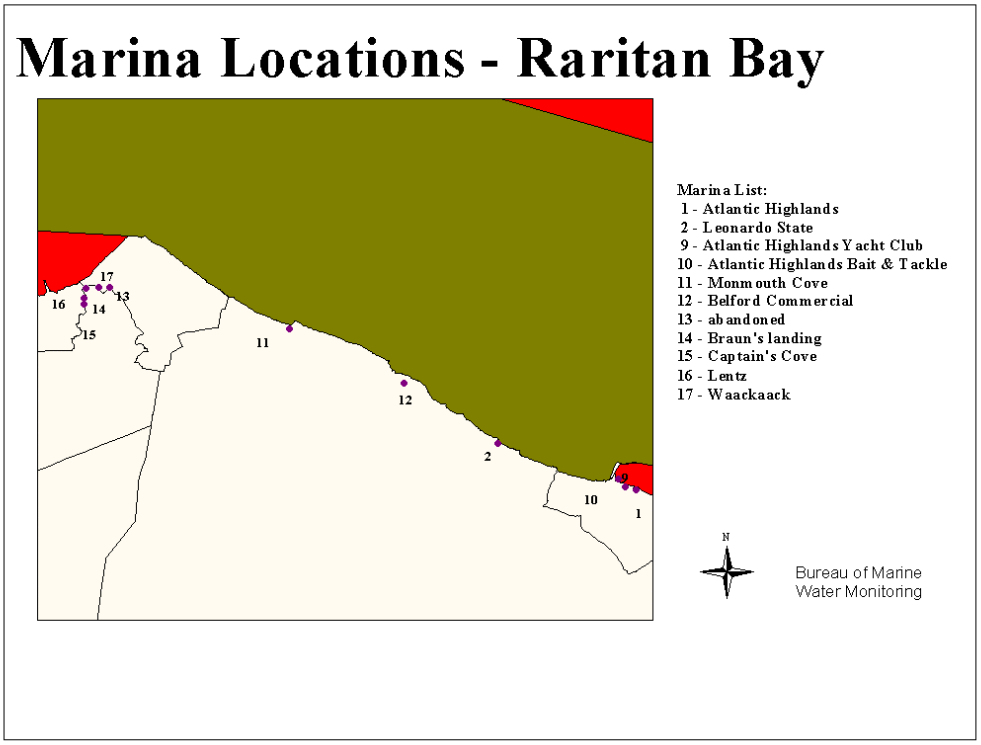


FIGURE 16 : MARINA FACILITIES LOCATED IN RARITAN BAY

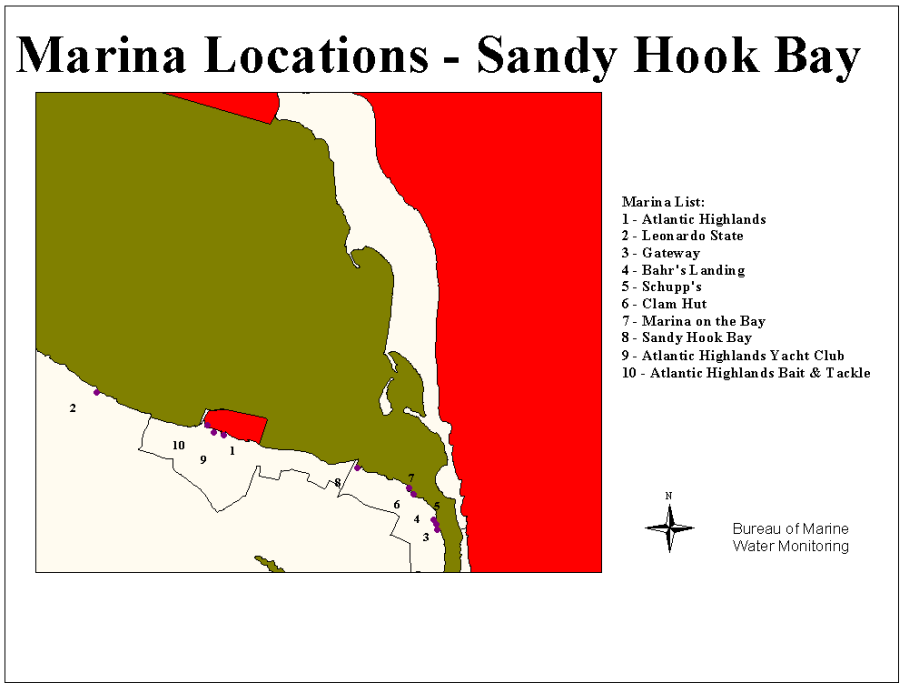


FIGURE 17: MARINA FACILITIES LOCATED IN SANDY HOOK BAY

There are 17 marinas (including the Belford commercial fishing fleet docks) located adjacent to *Special Restricted* waters between Conaskonk Point and the Route 36 Bridge at Highlands (Table 3 and Figure 16). Marine pump-out facilities for boat holding tanks are provided at the Leonardo State Marina, the Atlantic Highlands Municipal Marina, and the Monmouth Cove County Marina. The waters enclosed by the marina are classified as *Prohibited*. Depending on the size of the marina and the water quality, water immediately adjacent to each marina may be classified as *Prohibited*, *Special Restricted*, or *Seasonally Approved* (no harvest during summer months when the marina is active).

Marina buffer zones were not calculated because the shellfish waters are classified as *Special Restricted*. Shellfish harvesting in these waters are only allowed under the Special Permit Program. There is no direct harvesting and marketing in this program, only relaying or depuration.

TABLE 4: MARINAS LOCATED IN THE RARITAN / SANDY HOOK BAYS

MARINA NAME	NUMBER OF SLIPS	LOCATION ON MAP
Atlantic Highlands Municipal Marina	480	1
Leonardo State Marina	179	2
Gateway Marina	154	3
Bahr's Landing/COZ Seas Marina	30	4
Schupp's Landing	38	5
Clam Hut Restaurant	24	6
Marina on the Bay	85	7
Sandy Hook Bay Marina	85	8
Atlantic Highlands Yacht Club	0	9
Atlantic Highlands Bait & Tackle	15	10
Monmouth Cove Marina, (County)	127	11
Belford Commercial Fishing Fleet	Est. 10	12
Abandoned,Waackaack Cr.	0	13
Braun's Landing	14	14
Captains Cove Marina	45	15
Lentz Marina	Est. 10	16
Waackaack Marina	82	17

Dredging Projects

There are numerous dredging projects proposed by the Corps of Engineers (COE) in the Port Newark, Newark Bay, Hackensack River, Raritan River Channel, Arthur Kill, Kill Van Kull, and Port Jersey areas. The COE has not asked the State of New Jersey to use New Jersey waters in the Raritan-Sandy Hook Bay as a dredge spoil disposal site. As far as the New Jersey Department of Environmental Protection's Office of Dredging and Sediment Technology is concerned, the Raritan-Sandy Hook Bay is "Off Limits" for dredge spoil disposal (Baier, 1998). However, the Corps has proposed locating a dredge spoils site in New York State waters (adjacent to New Jersey waters) at Flynn's Knoll.

Landfills

Two closed landfills are located along the shoreline in Keyport and Belford. Both landfills extend to the shoreline of the bays. Both landfills appear to occupy areas formerly covered by wetlands and tidal marsh deposits. The elevation of each landfill is approximately 10 feet above sea level. The landfill in Keyport operated under the name of WDI . This was a private landfill that was closed in

1979. The landfill located in Belford, Middletown Township was also a private landfill that closed in 1977. Monmouth County currently owns it and intends to develop the property into a ferry site. No problems have been reported at either landfill that would impact marine water quality (Chojnacki, 1998). Groundwater sampling from the landfills is not required because they closed prior to 1982.

Other Potential Inputs

Information in the Bureau's file indicates that a former coal gasification plant was located along the banks of Many Mind Creek in Atlantic Highlands many years ago. The environmental impact (if any) of this abandoned site on the marine waters of Sandy Hook Bay and shellfish resources of the area is unknown. It should be noted that the New Jersey Department of Environmental Protection Site Remediation Program has not verified that any known or abandoned contaminated waste sites directly impact the marine waters or the shellfish resources of the Bay.

There are numerous identified sites listed as "Known Contaminated Sites" or "Toxic Release Inventory Sites". However, there is no evidence to indicate that any of these sites adversely impact the shellfish waters at this time. Likewise, the identified discharges to ground water are not located adjacent to the Bay and there is no evidence that any of those permitted discharges adversely impact shellfish waters at this time.

The area is not adversely impacted by agricultural practices, livestock or wildlife populations.

Presence of Toxicants

Atlantic Highlands Marina Area

In 1984, the New Jersey Department of Environmental Protection, Bureau of Marine Water Monitoring, identified elevated levels of lead and chromium in the soft clam, Mya arenaria, in the vicinity of the Atlantic Highlands Municipal Marina (Feerst, 1984). This area has been excluded as a shellfish harvesting area.

Mussel Watch Data

In 1986, the National Oceanic and Atmospheric Administration (NOAA) National Status and Trends Program included a component called the Mussel Watch Project that has annually collected and analyzed mussels and oysters from 276 sites around the coastal and estuarine waters of the United States. Of these, 125 sites (46%) are within 20 km of urban areas. It should be noted that both the blue mussel and the oyster accumulate most toxicants at a higher rate than either hard or soft clams, so that tissue concentrations in those species would ordinarily be higher than concentrations in clam tissue sampled in the same area.

One of these sites is located in this area approximately two miles northwest of Sandy Hook in *Prohibited* waters. Another site is located approximately three miles north of Conaskonk Point in New York State waters.

At the site located northwest of Sandy Hook, the blue mussel, Mytilus edulis, was identified as having 'relatively high' concentrations of copper, mercury, nickel, lead, chlordane, dieldrin, DDT, PCB's, and PAH's (NOAA, 1998). The 'relatively high' concentration was defined as the high end of the overall distribution of concentrations in mollusks at the 36 most urban sites (over 800,000 people) being monitored. The chemical analysis was based on dry weight concentrations.

The 'relatively high' designation by the Mussel Watch Project does not necessarily mean that FDA Standards have been exceeded based on wet weight concentrations. An evaluation of the data by the Bureau of Marine Water Monitoring found that only the levels of lead in the blue mussel at the site near Sandy Hook exceeded the FDA's recommended criteria based on wet sample analysis. It should be noted that the blue mussel tends to accumulate toxicants such as metals at higher rates than clams.

Sampling and analysis of the hard clam, Mercenaria mercenaria, was not included in the Mussel Watch Project.

Bathing Beach Data

For the period of time covered by this report there have been no problematic bathing beach closures in this area due to elevated bacteria. Precautionary closures were instituted in reaction to the MCBOA discharges described above. (Loftin, 1998).

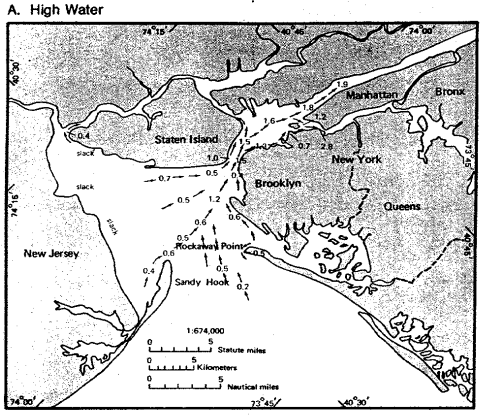
HYDROGRAPHY AND METEOROLOGY

CIRCULATION

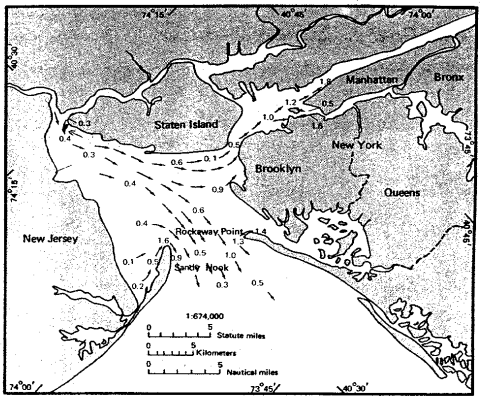
Hydrographic studies have found that the mixing of fresh water from Raritan River and saltwater from lower bay creates a large, slow moving counter-clockwise circulation pattern with much back-and-forth movement within Raritan Bay. Fresh water entering the bay from the Raritan River has a net movement toward the ocean of about 500 yards a day, and so it takes 16 to 21 days for the bay to flush itself (Bennett, 1983). Tidal action represents a major influence in the distribution of pollutants in the estuary, with a mean tidal range of 1.5 meters (5 feet). Tidal current and flow velocity charts for the New York Harbor area, including Raritan and Sandy Hook Bays, are depicted in the following figures published by the U.S. Department of Commerce (NOAA, 1956).

FIGURE 18: CIRCULATION IN RARITAN / SANDY HOOK BAY

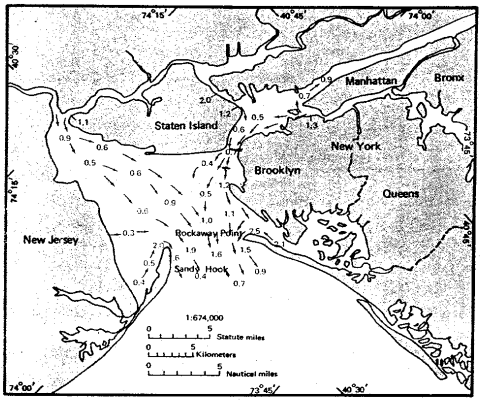
A. High Water



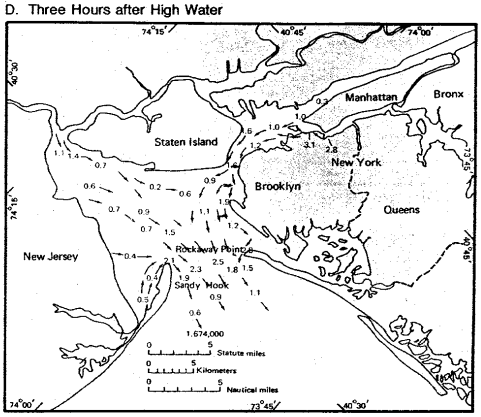
B. One Hour after High Water



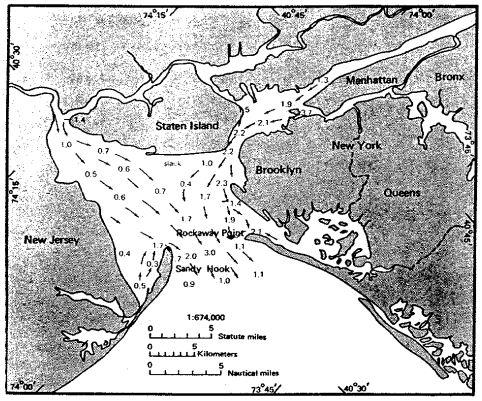
C. Two Hours after High Water



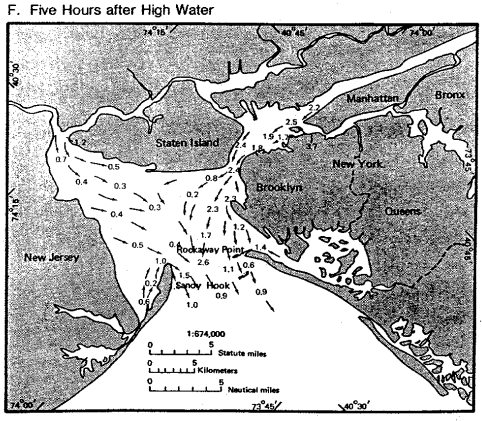
D. Three Hours after High Water



E. Four Hours after High Water



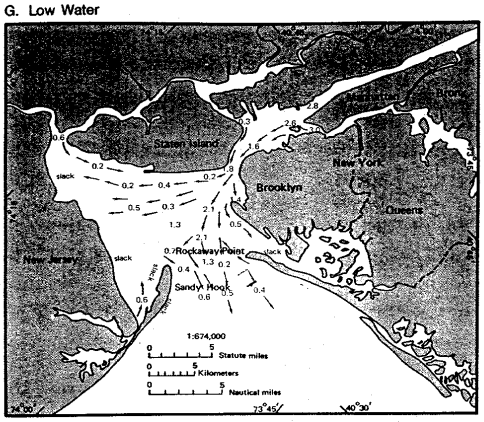
F. Five Hours after High Water



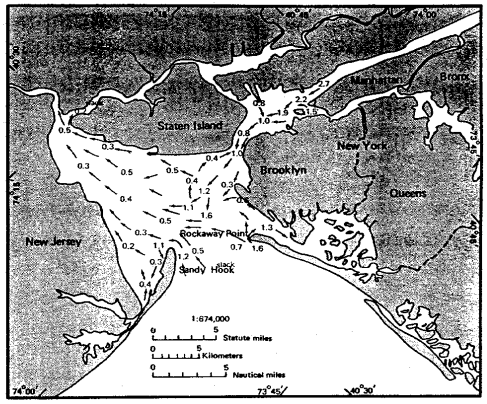
EBB TIDE

FLOOD TIDE

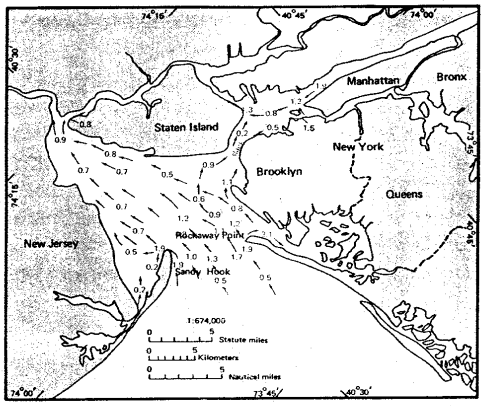
G. Low Water



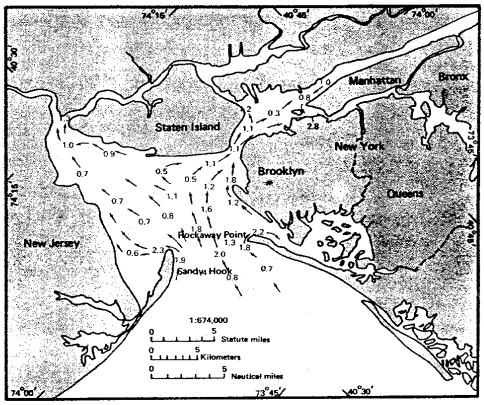
H. One Hour after Low Water



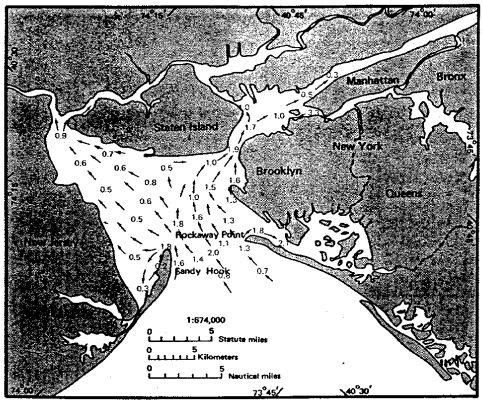
I. Two Hours after Low Water



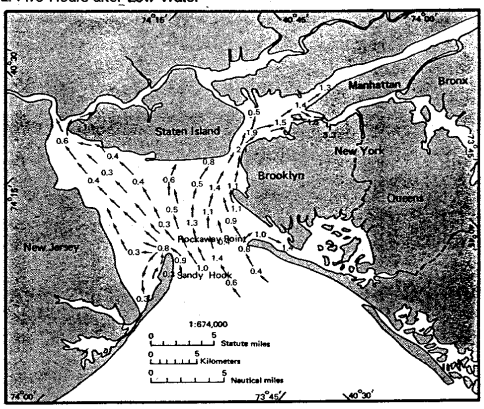
J. Three Hours after Low Water



K. Four Hours after Low Water



L. Five Hours after Low Water



Transverse Mercator Projection

Source: Coast and Geodetic Survey 1956

PRECIPITATION

Precipitation records for the period covered by this report are shown in Appendix C. There have been no significant changes in hydrography since the last report (Scro, 1996). The primary weather station is Sandy Hook. The secondary weather station is Newark International Airport. The secondary station is used when data from the primary station is incomplete. Since 1995, the primary station has been Newark. For the period of time covered by this report approximately 50% of the rainfall data was from Newark International Airport.

Normally, the Bureau determines if sampling stations show increasing MPN values with rainfall using an analysis of correlation coefficients. Correlation analysis looks at paired observations (total coliform MPN and rainfall amounts) and assesses whether, on average, one variable increases or decreases as the other variable increases.

Evaluation of rainfall data for the period of time covered by this report do not show an increase in MPN values with increasing rainfall within 48 hours prior to sampling (Appendix C).

However, since all samples were obtained after rainfall, (i.e., there were no dry weather samples), it is unlikely that a significant correlation between precipitation and coliform MPN value would be found. Typically, such a correlation can be demonstrated only when samples are obtained under varying conditions, including dry weather, after storms of low intensity and/or duration, and after storms of high intensity and/or duration.

WATER QUALITY STUDIES

SAMPLING STATIONS

A total of 771 water samples from 64 stations were analyzed for total coliform (TC) and fecal coliform (FC) bacteria during the period August 24, 1994, through May 8, 1997. The United States Environmental Protection Agency (USEPA) and the Interstate Sanitation Commission (ISC) provided valuable assistance in sample analysis and sample collection. The ISC performed numerous sampling runs for this report. The USEPA Region II Environmental Science and Assessment Laboratory in Edison, NJ. completed the analysis on samples collected by the ISC for sampling runs completed on January 29, 1997, and February 6, 1997. The data for this report was collected over a total of 22 sampling runs. Samples are collected under the adverse pollution condition of rainfall.

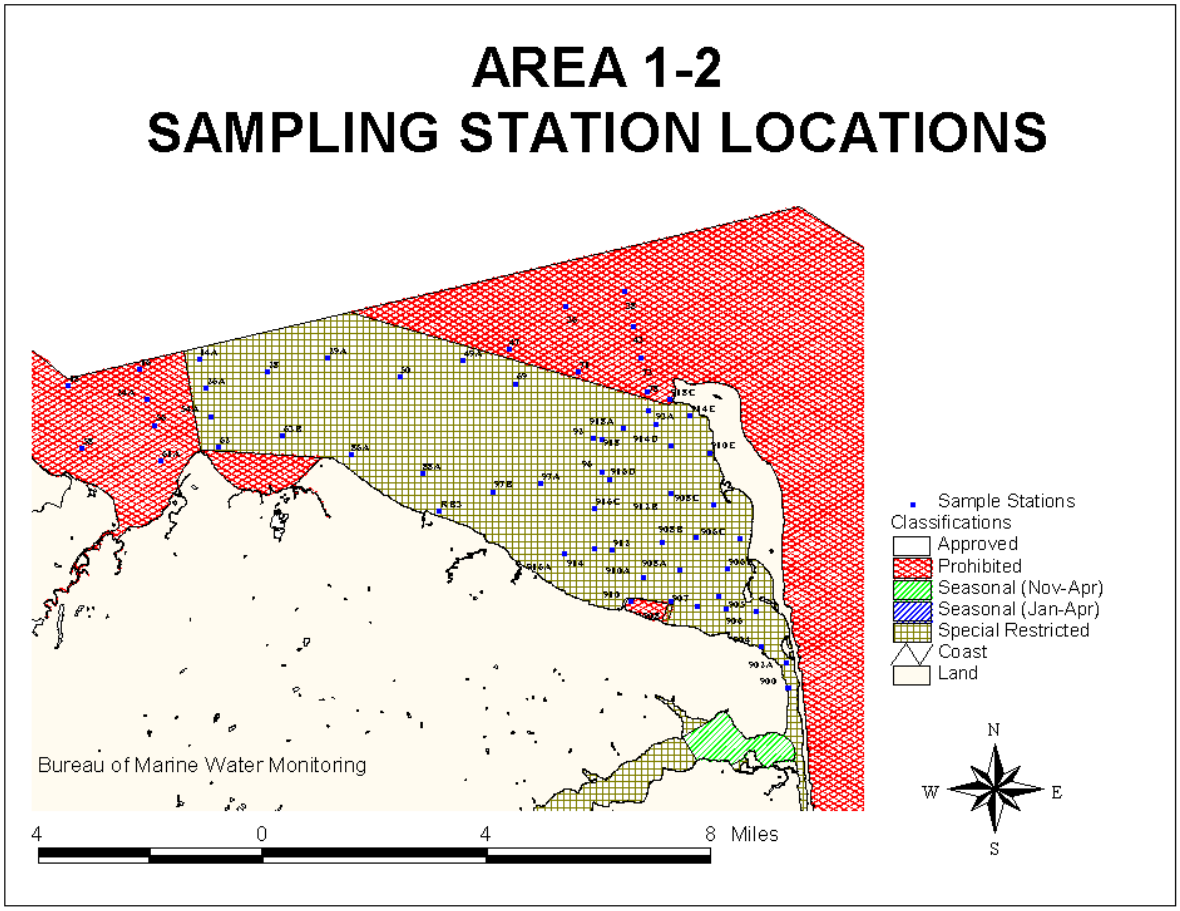


FIGURE 19: SAMPLING STATIONS

EVALUATION OF DATA COLLECTED IN SPECIAL RESTRICTED WATERS

Raritan and Sandy Hook Bays consist of *Special Restricted* and *Prohibited* waters. The *Special Restricted* waters were classified based on 518 samples from 26 sampling stations having a minimum of 15 data sets. The remaining sampling stations in *Special Restricted* waters (where insufficient data was available for classification) support the *Special Restricted* classification. Evaluation of the bacteriological data indicates that the *Special Restricted* waters are correctly classified and that no change in classification is necessary. Each of the 26 sampling stations meet the total coliform (TC) bacterial criteria in the NSSP Model Ordinance, 1997 Revision for *Special Restricted* classification.

FIGURE 20: SAMPLING STATIONS NOT MEETING SPECIAL RESTRICTED WATER QUALITY CRITERIA

Each of these 26 sampling stations were evaluated on a year-round basis during the period covered by this report. The evaluation indicates that these data exceed the *Approved* water criteria

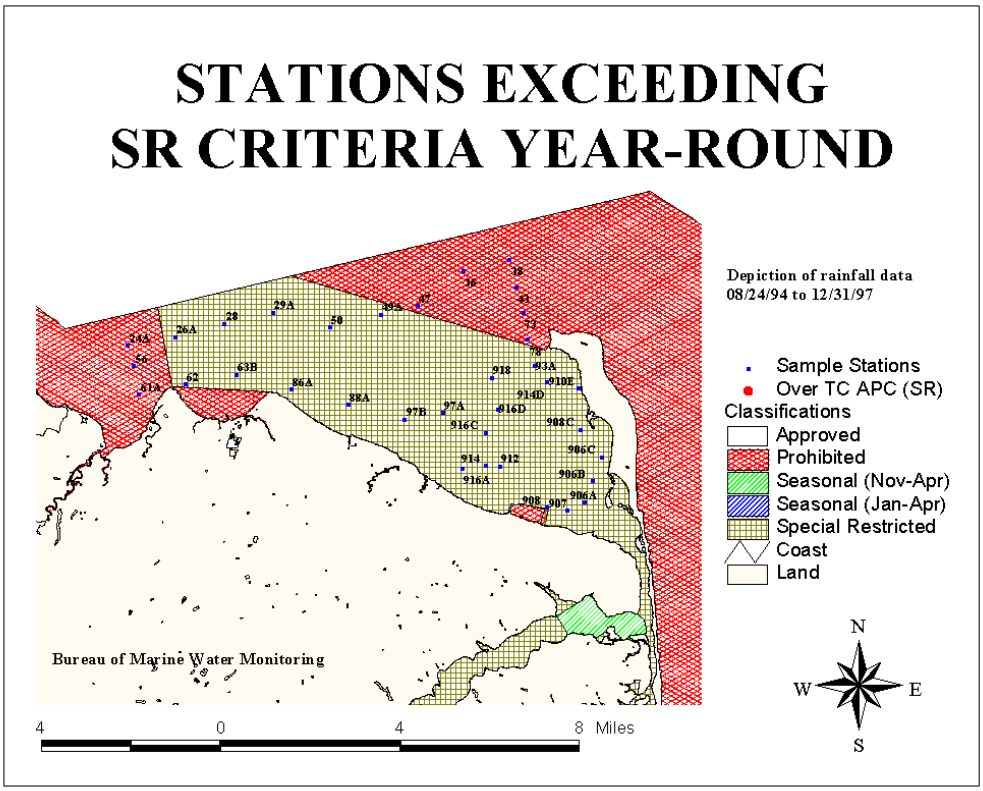
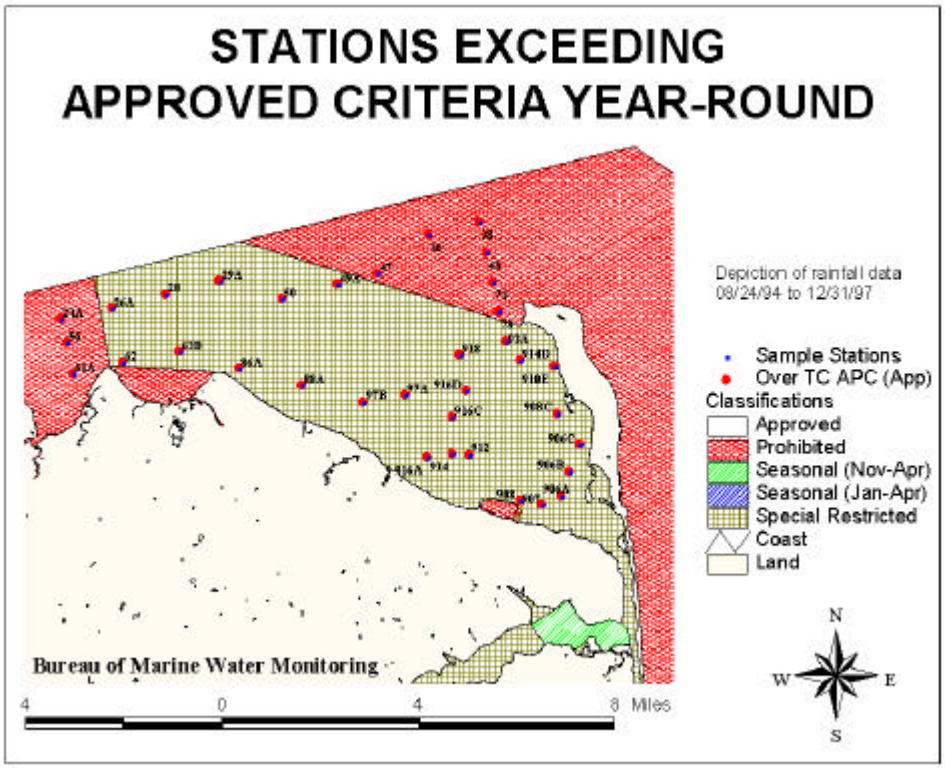


FIGURE 21: AREAS NOT ACHIEVING CRITERIA FOR *APPROVED* SHELLFISH WATERS



EVALUATION OF DATA COLLECTED IN PROHIBITED WATERS

There are nine sampling stations with a minimum of 15 data sets that are located in *Prohibited* waters. Three of these stations are located in Raritan Bay between Keyport Harbor and Conaskonk Point. The other six stations are located in Lower Bay, northwest of Sandy Hook. All nine stations located in the *Prohibited* waters meet the bacteriological criteria for *Special Restricted* classification. The remaining stations in *Prohibited* waters (with less than 15 data sets) also support the bacteriological criteria for *Special Restricted* classification. Each of these nine sampling stations that were evaluated on a year-round basis during the period covered by this report exceeds the *Approved* water criteria.

TIDAL EFFECTS

For the period of time covered by this report the coliform values were not influenced by tide, or season and precipitation does not significantly increase MPN values of the sampling stations on a year-round basis.

SEASONAL EFFECTS

Data were evaluated to determine if seasonal variation had a significant effect on water quality. To complete this analysis, it was necessary to use data from 1990 through 1997 for the winter months and from 1992 through 1997 for the summer months. From 1990 to 1992 samples from this area were analyzed for fecal coliform using the A-1 methodology, but not for total coliform. Since these data can not be compared with total coliform data generated using the three-tube MPN methodology, it was necessary to use a longer period of time to have sufficient data (minimum 15 data points) for the analysis.

Winter

When winter data since 1990 are used (to obtain a sufficient number of samples), each of the 15 sampling stations evaluated during the Winter sampling runs (November 1 through April 30) exceed *Approved* water criteria (Appendix F).

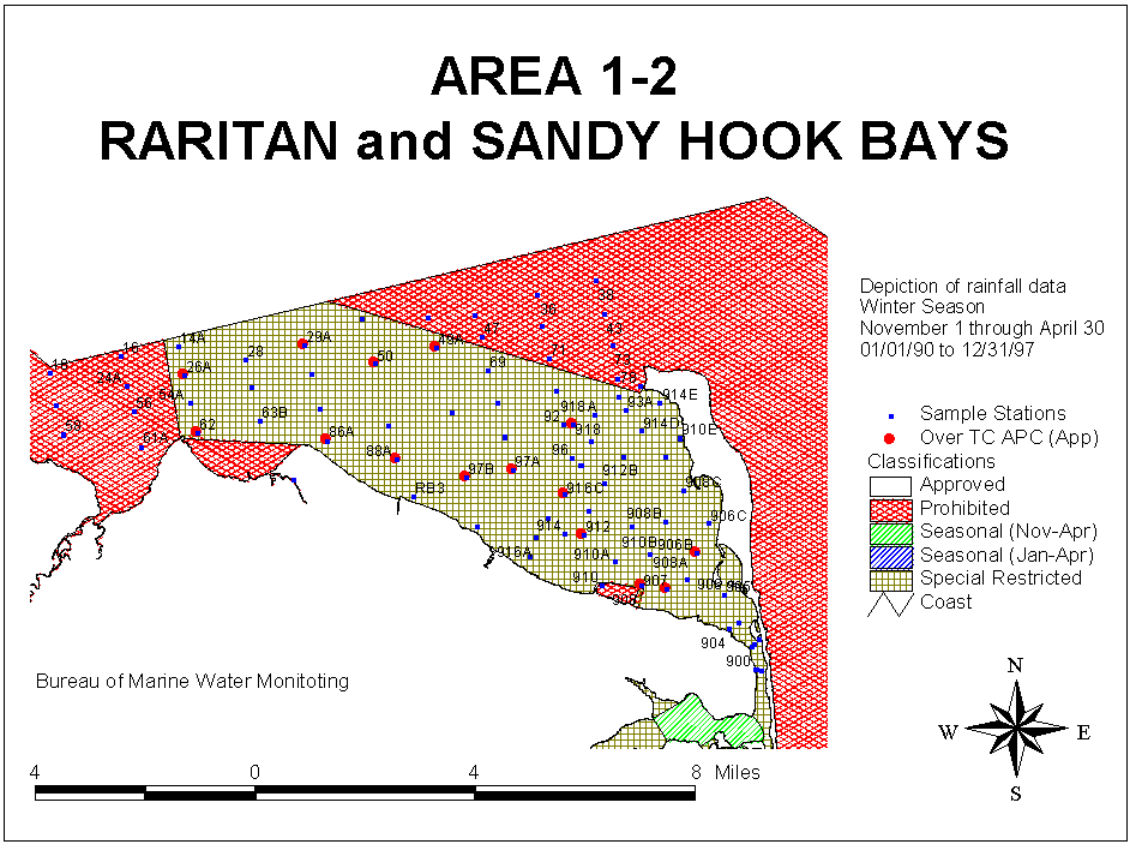


FIGURE 22: AREAS NOT ACHIEVING *APPROVED* SHELLFISH WATER CRITERIA DURING THE WINTER

Summer

When data since 1992 are used (to obtain a sufficient number of samples), there are 7 out of 15 sampling stations which exceed *Approved* water criteria during the summer sampling runs (May 1 through October 31)). Eight of the 15 sampling stations meet *Approved* water criteria (Appendix F). These 8 stations are located in Sandy Hook Bay. It should be noted that not all of this data was obtained after rainfall, so that the evaluation may not properly assess the water quality for the purpose of classifying the waters.

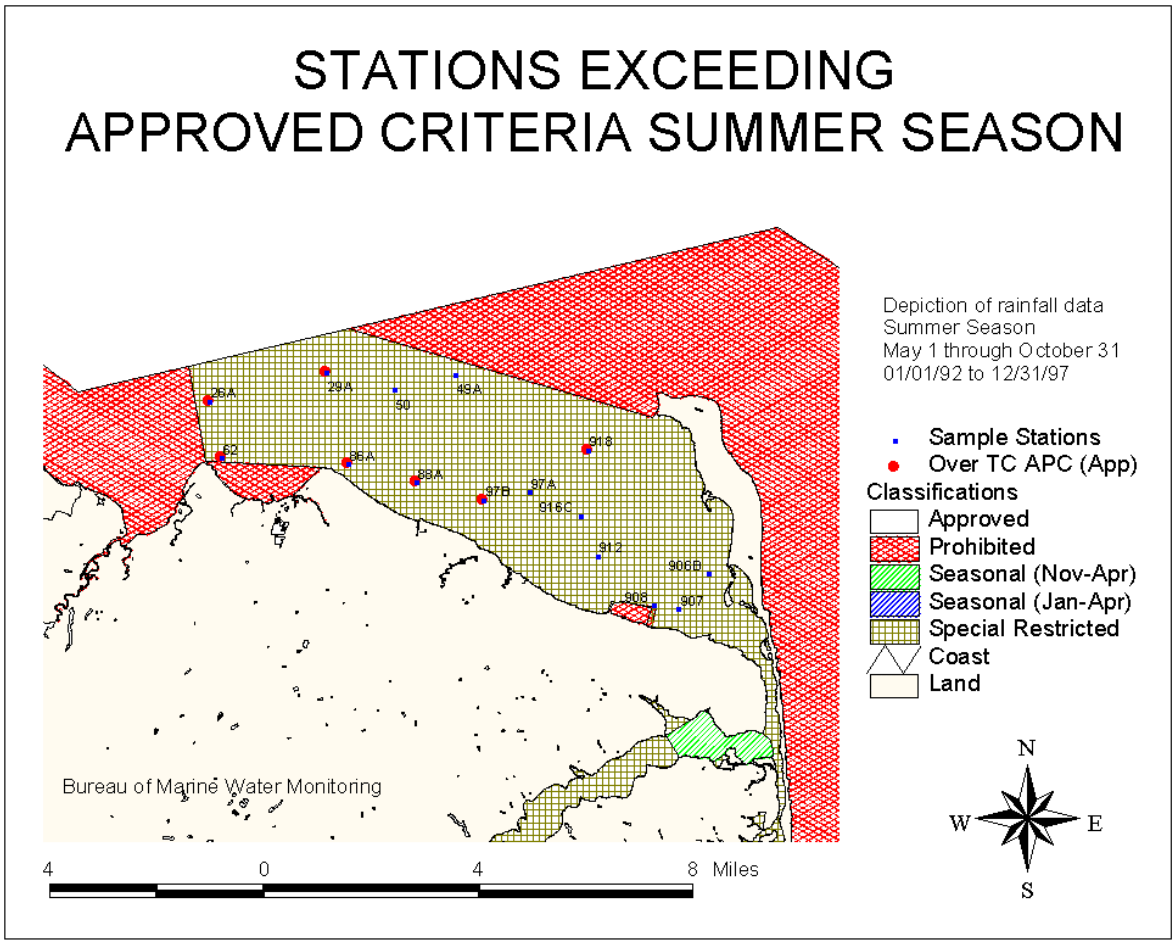


FIGURE 23: AREAS NOT ACHIEVING *APPROVED* SHELLFISH WATER CRITERIA DURING THE SUMMER

INTERPETATION AND DISCUSSION OF DATA

Analysis of the bacteriological data collected during the period 8/24/94 through 5/8/97 is shown the appendices.

A review of the data collected in Raritan and Sandy Hook Bays shows no significant change in water quality and supports the existing shellfish growing water classification for this area (*Special Restricted)*. All 35 sampling stations that were evaluated exceeded *Approved* water criteria. All of the stations meet or support the *Special Restricted* standard.

The year-round water quality of Sandy Hook Bay appears to be improving. All stations evaluated in Sandy Hook Bay meet the median value for *Approved* water criteria however all stations exceed the percentage criteria (range 11.1 to 18.8 %). The percentage criteria is a statistical measure of the variability of the data. Since the analysis of biological data is inherently variable, it is critical to the appropriate evaluation of the data to consider the central tendency (by using the median value) and the variability (by using the percentage exceeding a given value, in this case 300 MPN, criteria.)

Sampling stations evaluated in the Raritan Bay generally exceed both the median and percentage criteria for *Approved* water classification and at higher values compared to the Sandy Hook Bay stations.

TABLE 5: RARITAN AND SANDY HOOK BAY YEAR ROUND DATA SUMMARY UNDER RAINFALL CONDITIONS 8/23/94 TO 5/8/97

Sandy Hook Station	No.of Samples	MPN Median	% >300	Raritan Bay Station	No. of Samples	MPN Median	% >300
906A	17	11.0	17.6	24A	17	240.0	41.2
906B	22	3.0	18.2	26A	21	300.0	47.6
906C	18	8.2	16.7	28	18	77.5	27.8
907	21	4.0	14.3	29A	22	68.0	22.7
908	22	9.1	18.2	36	18	86.5	5.6
908C	18	9.1	11.1	38	18	84.0	16.7
910E	17	9.4	11.8	43	18	71.5	11.1
912	22	9.1	13.6	47	18	93.0	11.1
914	17	7.3	17.6	49A	22	111.5	18.2
914D	16	26.0	18.8	50	22	61.5	13.6
916A	17	11.0	11.8	56	18	240.0	38.9
916C	22	9.1	13.6	61A	17	150.0	23.5
916D	17	43.0	11.8	62	21	240.0	38.1
918	22	26.5	13.6	63B	18	62.5	27.8
Sandy Hook	No.of	MPN	% >300	Raritan Bay	No. of	MPN	% >300

Station	Samples	Median		Station	Samples	Median	
				73	18	68.0	16.7
				78	18	41.0	11.1
				86A	22	59.0	18.2
				88A	22	33.0	27.3
				93A	18	59.0	11.1
				97A	22	33.0	18.2
				97B	22	23.0	18.2

The water quality degradation of the Raritan Bay, and to a lesser extent the Sandy Hook Bay is most likely the result of:

1. Nonpoint pollution associated with
   - Degraded water quality of major tributaries which drain to the bay,
   - Topography of the mainland shore which directs storm drains and overland stormwater runoff to the bay, and
   - Marina and boating activities.
2. Antiquated infrastructure, where infiltration and inflow of sanitary sewage into stormdrains occurs (Scro, 1992).

There appears to be an overall improvement in bacterial water quality in Sandy Hook Bay and to a lesser extent in the Raritan Bay during the summer from May through October. However, in the recent past, sampling has been limited to the winter months. Additional samples should be collected and analyzed under the adverse pollution condition of rainfall during the summer months to properly assess this trend .

TABLE 6: COMPARISON OF WINTER VS. SUMMER DATA SUMMARIES

SUMMER SAMPLING SEASON May-October, 1992-1997				WINTER SAMPLING SEASON November-April, 1990-1997		
Station	**No. of Samples**	**MPN Median**	**%>300**	**No. of Samples**	**MPN Median**	**%>300**
49A	18	19.0	5.6	16	150.0	31.3
50	18	3.3	5.6	16	93.0	18.8
97A	18	3.6	0.0	16	43.0	31.3
906B	17	3.0	5.9	15	3.6	20.0
907	15	3.6	0.0	15	9.1	20.0
908	18	6.4	5.6	15	8.0	26.7
912	18	3.6	0.0	15	9.1	26.7
916C	18	8.2	0.0	15	9.1	20.0
26A	18	8.2	16.7	15	460.0	60.0
29A	18	3.0	11.1	16	140.0	31.3
62	18	3.6	11.1	15	460.0	53.3
86A	18	18.5	11.1	16	195.0	31.3
88A	18	6.4	16.7	16	68.0	31.3
97B	18	3.3	11.1	16	23.0	25.0
918	18	12.1	11.1	15	13.0	20.0

CONCLUSIONS

CLASSIFICATION

All sampling stations located in the *Special Restricted* waters meet or support *Special Restricted* criteria under the adverse pollution condition of rainfall.

All sampling stations located in the *Prohibited* waters meet or support the bacteriological criteria for *Special Restricted* classification under the adverse pollution condition of rainfall.

Current data supports the present classification. No change in classification is required at this time.

UPGRADE OF PROHIBITED WATERS

Insufficient bacteriological data is available to make a recommendation at this time. (See Recommendations.)

Mussel Watch data regarding the presence of toxic parameters in shellfish tissue is a concern. Current data regarding toxic parameters in sediment and hard clams are necessary to make a recommendation regarding upgrades in either the eastern or western portions of the Bay. (See Recommendations.)

SAMPLING

There are eleven creeks located between Highlands and Conaskonk Point that discharge to the *Special Restricted* waters of Raritan and Sandy Hook Bays.

The bacterial levels in these tributaries and the potential impact on water quality and the shellfish resources in unknown.

RECOMMENDATIONS

CLASSIFICATION

No change in classification is recommended. Raritan and Sandy Hook Bays are properly classified.

SAMPLING

Inactive sampling stations 5, 7, 33A, and 34 located in *Prohibited* waters should be reactivated and included in the 1998-1999 sampling schedule. There is no recent water quality data for these sampling stations. (A total of 6 sampling runs have been scheduled for these sampling stations for 1998-1999.)

Sampling stations in Sandy Hook Bay should be sampled during the summer months after rainfall to assess the possible water quality trend that was identified in this report. Since the existing summer data is several years old and was not collected after rainfall, this data would be important to assess water quality in the eastern portion of this area. Although these sampling runs have not been scheduled for the 1998-1999 sampling year, consideration should be given to scheduling a monthly sampling run after rainfall during summer months.

Additional sampling and analysis for certain other toxicants should be performed prior to any upgrade in classification of *Prohibited* waters to *Special Restricted* status. Shellfish tissue and sediment samples should be evaluated for the presence and concentration of As, Cu, Ni, Cr, Pb, Hg, Cd, Chlordane, Dieldrin, DDT, PCB's and PAH's.

Establish sampling stations to provide data to evaluate the impact of the tidal streams on the water quality in the bay. The sampling stations should be included either in the established sampling runs (where practical) or through the RATS (River Assessment) sampling program.

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APPENDICES

A. Statistical Summaries: 8/24/94 through 12/31/97 Rainfall Conditions

1. Year Round
2. Winter
3. Summer

B. Seasonal Evaluation Summer vs. Winter Data

C. Precipitation

1. Rainfall Correlation
2. Cumulative Rainfall

D. Tidal Evaluation Ebb vs. Flood Tide Data

1. Year Round
2. Winter
3. Summer

E. Detailed Data Listing 8/24/94 through 12/31/97

1. Year Round
2. Winter
3. Summer

F. Supplemental Data

1. Winter 01/01/90 to 12/31/97
2. Summer 01/01/92 to 12/31/97
3. Fecal Coliform data analyzed with A-1 methodology (1990-1992)